Chapter 3: Characterization of Superfund Responses

Of the approaches used in the Superfund program described in Chapter 1, responses, including both removal actions and remedial actions, are the most complex, account for a majority of Superfund spending, and probably account for most of the benefits. To support the benefits transfer analyses in Chapters 4 and 5, this Chapter describes Superfund responses, quantifies them, and characterizes sites on the National Priorities List (NPL). Superfund responses to uncontrolled releases of hazardous substances are taken by the federal government directly under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Superfund Amendments and Reauthorization Act (SARA), as well as response actions taken by states and private parties to the degree that CERCLA and SARA provide a basis for those actions.[1] This Chapter is organized in three major parts: first, Superfund responses are described; second, methods used to quantify responses are presented and applied; and third, sites on the National Priorities List (NPL) are characterized.

Description of Superfund Responses

<u>Overview</u>

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP, 40 CFR 300) is the regulation that specifies how CERCLA remedial and removal actions are conducted. The NCP was first established in 1968 to deal with oil spills. CERCLA added authority to respond to uncontrolled releases of hazardous substances in a manner consistent with the NCP. Today the NCP is managed jointly by the U.S. Coast Guard and the Environmental Protection Agency (EPA), and the program involves over 16 federal agencies, as well as many state and local representatives. The NCP provides a national framework for emergency response capabilities and promotes coordination among the hierarchy of responders and contingency plans. A Superfund response is triggered by the discovery of a hazardous substance release, or a substantial threat of a release. CERCLA Section 101 defines a release as "… any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant.)" The release must be of a hazardous substance as defined in CERCLA or must present an imminent or substantial danger to public health or welfare. Petroleum spills are specifically excluded from the authority of the Superfund program and are ignored here.

Many CERCLA responses involve the enforcement of CERCLA's liability provisions, in which EPA seeks to identify the potentially responsible parties (PRPs) – those individuals or organizations responsible for creating or contributing to uncontrolled releases of hazardous substances. CERCLA's two basic liability provisions permit EPA to either compel a PRP to abate an endangerment to public health, welfare, or the environment, or to recover the costs of response. The law also provides for citizen suits to enforce CERCLA's provisions (Section 310), and it provides authority for federal agencies, states, and tribes to bring actions for damages to natural resources (Section 107).

[1] The current study defines Superfund responses as those responses to uncontrolled releases of hazardous substances that can be attributed to the Superfund program.

Liability can extend to site owners, facility operators, waste transporters, or anyone who generates hazardous substances that contaminate other sites. This liability is strict, joint, and several, with no requirement that a PRP's hazardous substance be the sole cause for a response action. Legal proof of negligence is not required, and conducting activities consistent with standard industry practices is not considered an adequate defense. The original draft of CERCLA contained no statute of limitations. This was altered in 1986 with SARA's inclusion of limits on recovery actions and natural resource damages.

Superfund responses address the continuum of health and environmental risks ranging from emergencies to long-term problems. Removal actions, in particular time-critical removals, provide for rapid response where the problem needs to be addressed in an urgent manner. They are typically used to respond to chemical spills, human health threats that might cause harm from short-term exposures (e.g., lead-contaminated residential soils), and situations that may cause a sudden release (e.g., leaking drums). The technological options that can be used (e.g., waste treatment, excavation and disposal, providing alternate water supplies) to conduct both removal and remedial actions are identical under the authority granted to EPA, except that permanent relocation of residents is specifically authorized only as a remedial action. However, removal actions are limited in monetary and temporal scope ($2 million and one year, with occasional exceptions). As a result, removal actions do not support the detailed investigation and planning needed to ensure that the locations of all hazardous substances on a site are identified, that the extent of contamination is fully characterized, or that all the hazardous substances on the site are treated. For this reason, detailed risk information is generally not available for releases associated with removal actions. In practice, the removal program is often used to address completed exposure pathways with high levels of exposure, and the remedial program is used to address such risks where there are future risks but no (or limited) current exposures, or where a completed exposure pathway is interrupted temporarily (e.g., with a fence).

Based on these regulations and complementary state laws and programs, EPA and the states have over time crafted a set of response options that are flexible and accountable, and that maximize PRP involvement in response actions. In situations where there is an obvious, immediate health risk, the NCP authorizes limited federal expenditures to deal with the problem. In situations where the cost of remediating a site is larger, the NCP requires more testing and analysis to determine more definitively the nature and extent of contamination and select the best method for dealing with the release. In both cases, the liability provisions of CERCLA and SARA apply, so PRPs can be required to reimburse EPA for the cost of remediation. This highlights the importance of the Trust Fund – it can be used to begin to address without delay releases that could be harmful to the public and then the costs incurred can be recovered from the PRPs. In part to avoid the liability provisions of the Superfund program and in part to restore more power to local decision-makers, the states have developed complementary programs to deal with releases, and PRPs have undertaken voluntary remedial actions (usually under the supervision of state Voluntary Cleanup Programs, or VCPs).

Thus, the primary distinction between NPL sites and other hazardous waste sites is often a question of whether federal authorities or resources will be needed, not the risks presented by the site, or even the cost of remedial action. For this reason, while NPL sites tend to have serious contamination problems, not all sites with serious contamination end up on the NPL, and the NPL does not include all of "the worst of the worst" (General Accounting Office 1998b, 1999; Varney 2000; Probst and Konisky 2001 pp. 75-6, 81-5). The key implication of this is that when considering the benefits of Superfund, examining only NPL sites is likely to be inadequate. Other response actions should also be included.

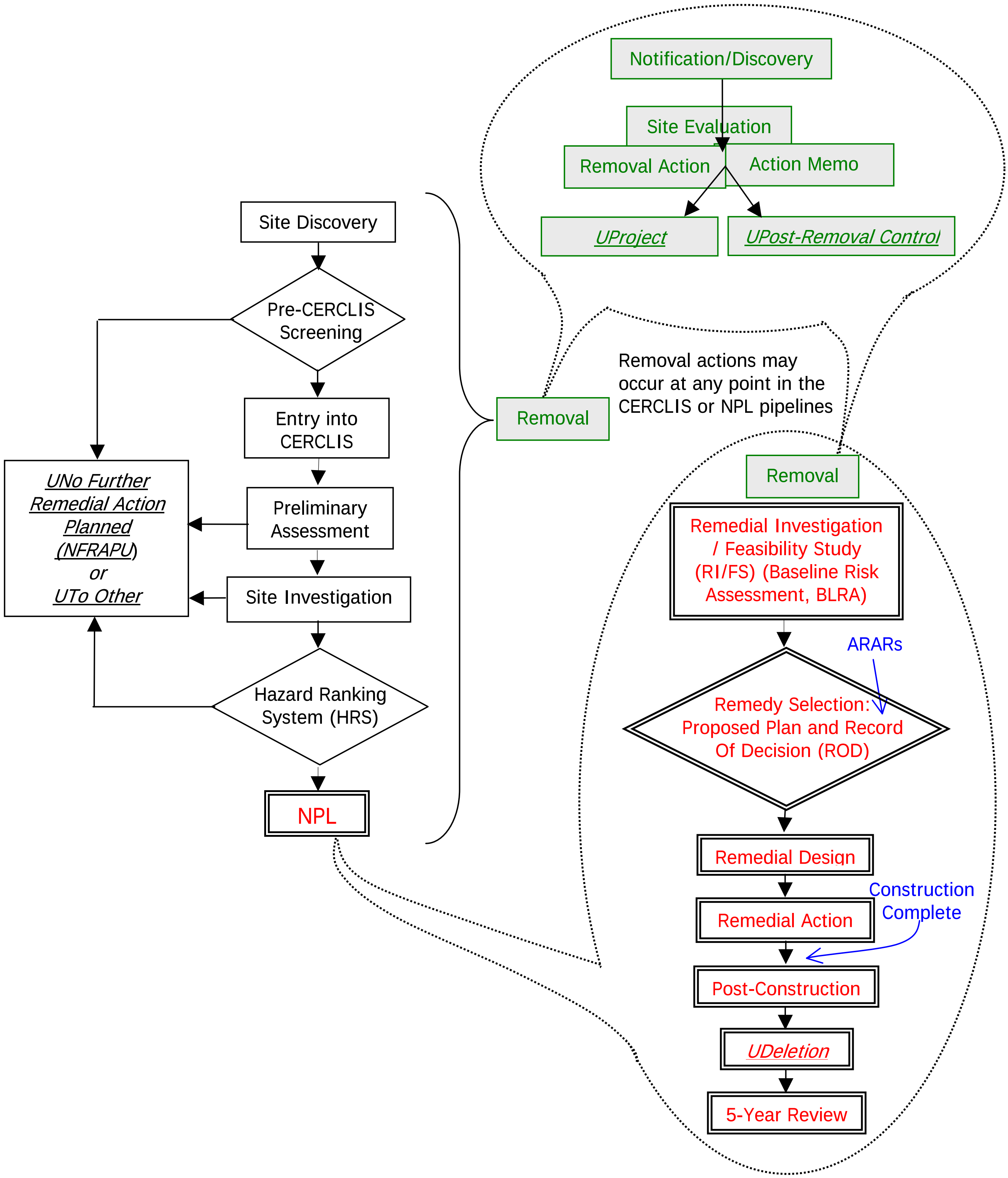
A simplified diagram of the processes (or "pipelines") for the various Superfund responses is shown in Figure 3.1.[2] Note that there are three essentially separate pipelines: a site screening or pre-remedial action (left pipeline); a removal action (upper right pipeline); and the remedial action (lower right pipeline). The site screening pipeline is used to sort out the many notifications and discoveries that are referred to EPA to ensure that each site receives an appropriate response, or receives no response if that is appropriate. It is important to keep in mind while reading the description of the site screening pipeline (as well as the NPL pipeline) that at any time during these processes the need for a removal action may arise, in which case the screening and analysis are temporarily stopped to deal with whatever immediate health risk has created the need for the removal action.

The use of the site screening process through the NCP has helped reduce the uncertainty associated with actual and potential releases. Local first responders (e.g., fire, police) and others who discover what they believe to be a hazardous substance release have a single place to report the discovery: the National Response Center (800-424-8802 or www.nrc.uscg.mil/nrchp.html). As a result, adequately trained personnel determine if the substance is hazardous, and if so, what to do about it. Many sites that were suspected of contamination by hazardous waste have been assessed through this mechanism, and most of them were found not to qualify for the NPL. Thus, the site screening process reduces the uncertainty associated with many potentially contaminated sites, which is generally considered a benefit in the *amenities* category (see Chapter 1).

Sites are not legally defined by property boundaries, but it is common to use property boundaries to describe sites. When a hazardous material is released into a medium (ground water, soil, surface water, or air), it may remain close to where it was released or it may migrate quite far, and sometimes rapidly. The release event, or series of events, implies a location, typically called the "site." The "release," often synonymous with the "site," is broadly defined in CERCLA as "any area where a hazardous substance release has 'come to be located.'" Often, this area does not match property boundaries.

[2] More information can be found at www.epa.gov/superfund/action/process/sfproces.htm.

Figure 3.1. Superfund Response Pipelines



The Site Screening Pipeline

Overview

A process of screening sites of releases and potential releases reduces the uncertainty about potential health or environmental risks at many sites around the country. This process is shown in the left-hand side of Figure 3.1 and is described below. If at any stage in this process an imminent and substantial threat is discovered, the site screening process stops to allow a removal action to address the problem promptly.

The site screening process has four possible endpoints, plus the potential to identify the need for one or more removal actions. First, some sites are eliminated from the process without formality because there is no risk (e.g., a sales office for pressure treated lumber that never harbored any hazardous substances). Second, sites may be entered into the screening process and evaluated, but eventually designated as requiring no further response action planned (NFRAP). In the latter case, the Superfund program is no longer involved, and these sites are designated as "archived." Third, some sites may go to other agencies (e.g., federal CWA officials or States). Fourth, sites may be proposed to the NPL, and after public comment be designated as final, which makes them eligible for remedial action funding. Each site that enters the site screening pipeline will end up at one of these four endpoints and may also have a removal action performed.

Site Discovery and Initial Screening

There are various ways in which uncontrolled releases of hazardous substances can come to the attention of EPA. Sometimes, the Agency discovers them through inspections or other investigations. For example, the contamination of a drinking water supply may be the initial sign of a release. If EPA conducts an investigation of a contaminated drinking water supply, the Agency will search the region for the sources of that contamination, and may identify sites requiring a response action. States discover most of the sites that require a Superfund response action, often through first responders, such as police, firefighters, and paramedic personnel. Other agencies within the federal government may refer sites to EPA, or site discoveries can result from information and reports from local authorities, businesses, and concerned citizens.

After discovery, the next step is an initial screening. EPA maintains a large database to track sites that may require a response action, called the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS). States perform much of the pre-CERCLIS screening work with EPA funding. This initial screening step comes before entering a site into CERCLIS, and ensures that the site represents a release or potential release that warrants Superfund assessment. For example, sites that are regulated under other federal authorities (e.g., the Clean Water Act (CWA)) that have their own cleanup processes would typically be screened out. Sites that are in other cleanup programs (e.g., state voluntary cleanup programs) might also be screened out. Moreover, some sites found through active discovery programs might not actually have handled hazardous substances and would not be entered into CERCLIS. For instance, the discovery of an uncontrolled release at a former chemical plant could result in a search for other properties owned by the firm that owned the chemical plant. Some of the properties identified in this way might be investigated. Others, such as a sales office that never had chemicals onsite, would be eliminated in the initial screening.

After pre-CERCLIS screening, sites are entered into CERCLIS, and are assigned a unique CERCLIS identification number. This number becomes the key to tracking all the elements of a site's history with EPA. Sites entered into CERCLIS are evaluated to determine what, if any, action is necessary under Superfund.

Site Assessment

EPA assesses all sites that are entered into CERCLIS. Initial site assessment comprises two phases: preliminary assessment (PA) and site inspection (SI). The PA is a relatively rapid, low-cost compilation of readily available information pertaining to the site and its surroundings. The data collected during the PA emphasize sensitive populations and other receptors or targets (e.g., ecosystems) that may be affected by contamination at the site. The SI builds on the PA by gathering enough information to determine whether a Superfund response or some other action (possibly by another agency) is warranted, or if no further remedial action is planned. During either of these steps it may be determined that no further response action is needed and the site will enter NFRAP status.

A key step in the site assessment process is the use of the Hazard Ranking System (HRS) to screen sites for potential inclusion on the NPL and for remedial action as defined by the NCP. The HRS is a standardized, objective method for providing an approximate quantitative evaluation of a potential release. Although the HRS characterizes the risks at each site and assigns a numerical score to those risks, it is only a screening process; the information does not provide in-depth site characterization.

Site Listing on the NPL

Most sites are listed on the NPL because they pass through the HRS screening process. If the HRS site score is greater than or equal to 28.5, the site is eligible for placement on the NPL, and therefore potentially warrants Superfund remedial action. Concurrence by the state in which the site is located is also required.[3] An HRS score below the cut-off yields a "No Further Response Action Planned" (NFRAP) designation. The cutoff score of 28.5 was developed in 1982 in order to meet a mandate in CERCLA that at least 400 sites be placed on the NPL. Because it is used as a screening tool and is not intended as a means of risk characterization, the HRS process is often halted once a score of 28.5 is reached. This is a means of conserving resources in the management of the Superfund program, but makes HRS scores unreliable for use in evaluating and comparing different sites.[4]

Sites may also be included on the NPL regardless of their HRS score if designated as the top priority by their state or territory. This can happen only once per state/territory, so only 56 NPL sites can ever be created this way (state roles in Superfund are discussed in more detail later in this chapter.) In addition, a site can be placed on the NPL if it meets one or more of three criteria: ATSDR issues a health advisory for the site recommending disassociation of the residents from the site; EPA determines that there is a risk to human health and/or the

[3] Initially required by appropriations language, this was institutionalized by EPA guidance in 1986.

[4] The truncation of HRS scores at 28.5 did not occur at the original set of 400 (approximately) NPL sites, which makes HRS values more meaningful for these sites.

environment; and EPA determines that a remedial action is more cost-effective than a removal action. EPA infrequently uses this last method for listing an NPL site.

The Removal Actions Pipeline

The NCP gives EPA the authority to respond rapidly to urgent problems associated with releases, such as chemical spills, human health threats that might cause harm from short term exposures (e.g., lead-contaminated residential soils), and situations that may cause a sudden release (e.g., leaking drums). A wide variety of response actions can be taken under this authority, such as waste treatment, excavation and disposal, or providing alternate water supplies. However, less permanent measures, such as erecting a fence to prevent access to the contaminated area and thus prevent exposure, are also common removal actions. In part, this is due to the limited monetary and temporal scope permitted for removal actions ($2 million and one year, with occasional exceptions), and in part due to the way EPA coordinates removal actions with larger, more complex remedial actions to ensure health and ecological risks are dealt with appropriately at all sites. In some cases (slightly less than 20% of the time) PRPs undertake removal actions with EPA or state supervision (Probst and Konisky 2001, 25).[5] In these cases, the limits on expenditures and duration do not apply.

There is extremely little quantitative risk assessment data about removal actions, but qualitative information can be found in several sources. Several researchers have documented significant reductions in exposure and risk from exposure during both remedial and removal actions (von Lindern et al. 2003; Sheldrake and Stifelman 2003; Khoury and Diamond 2003). This is the only quantitative evidence that removal actions may significantly reduce risk.

The qualitative evidence begins with the dramatic examples of removal actions provided in Table 3.1 and several of the case studies included here, such as LCP Chemicals on page 3-10 and RSR smelter on page 4-21. These examples suggest that for some removal actions, at least, significant hazards are being addressed.

It is useful to observe that the NCP authorizes EPA to use the same techniques in removal actions as in remedial actions, with the exception of permanent relocation of neighbors. This includes permanent remedies like incineration or other disposal, as well as simpler approaches such as erecting fences or otherwise limiting site access. Several of the case studies illustrate the sorts of techniques used in removal actions. However, some techniques used in remedial actions – such as the long-term treatment of contaminated ground water – are not used in removal actions. In a situation where ground water used for drinking was discovered to be contaminated by a release, a removal action might provide alternative drinking water on a temporary basis while a remedial action might treat the ground water so that it could eventually be used again as a drinking water source. Thus, in terms of techniques employed, removal actions are limited in comparability.

The other qualitative evidence comes from statements made in the literature. Essentially all analysts who have considered the question of whether removals mitigate significant real risks

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[5] Note that Probst and Konisky excluded federal facilities from most of their analyses, which may lead to differences in total cases they report versus those of other researchers.

have come to the conclusion that they do (Koshland 1991; Hird 1994; Wildavsky 1995; General Accounting Office 1995; Office of Management and Budget 2003). For instance, Hird notes removals prominently in his section on "Superfund's Overlooked Accomplishments" and goes on to say: "Indeed, much of Superfund's success lies with the removal action program, which has removed more than 2,600 immediate threats to heath and the environment since 1980 and has reduced substantial risks at many sites at relatively little cost. Thomas Grumbly, former Director of Clean Sites, Inc. and former U.S. Department of Energy Assistant Secretary for Environmental Management, stated that EPA's removal program, 'has probably eliminated most of the *immediate* health risks posed by abandoned hazardous waste sites'" (Hird 1994, 29-30, 112). There are some qualitative comparisons between removal and remedial actions: "… these emergency activities may operate in tandem with, *or as replacements for*, the remedial process…" (Hird 1994, 19 emphasis added). An OTA report noted that removal actions can resemble a remedial cleanup (Office of Technology Assessment 1989, 7, box). These comparisons are not quantitative, but they provide support for the idea that some removal actions result in significant health benefits.

EPA classifies removal actions into two types: time-critical, and non-time-critical.[6] To provide an example of typical removal actions, parts of a table from Probst and Konisky (2001, 20-21) are reproduced below in Table 3.1. In addition, several of the case studies contained in this report provide examples of removal actions. See, for instance, the LCP Chemicals case study on page 3-10. The other case studies are listed in Appendix B.

Table 3.1. Examples of Removal Actions

Type of Removal	Example Actions
Time-Critical	▪ Respond to truck accidents and train derailments involving chemical releases ▪ Temporarily provide bottled water to homes with contaminated water supplies ▪ Remove and dispose of chemicals abandoned by roadsides or in vehicles ▪ Respond to fires and explosions involving chemicals at operating or abandoned facilities, tire fires, and so forth ▪ Clean up and monitor mercury contamination at schools and private residences where children have played with metallic mercury ▪ Clean up and monitor chemical releases due to natural disasters (e.g., floods) ▪ Restrict access to and remove and dispose of chemicals at abandoned or bankrupt facilities or warehouses that may be subject to vandalism or fires (e.g., small electroplating shops, illegal drug production sites) ▪ Stabilize mining wastes to prevent releases to surface and ground waters
Non-Time-Critical	▪ Remove "hot spots" ▪ Install ground water treatment systems for contaminated ground water in conjunction with the remedial program

Source: (Probst and Konisky 2001 Table 2-3)

There is very little unified, systematic data characterizing the kinds of activities conducted during removal actions and the risk reduction associated with them. The most important information created through this process is included in the Action Memo for each removal (see Figure 3.1), but Action Memos do not include detailed risk information and are not readily accessible. As of the end of FY 2003, EPA had completed approximately 7,400 removal

6 Probst and Konisky (2001, 17) and others use a third category ('emergency' removals) but this is not an official EPA designation.

actions.[7] Over the last decade, an average of 430 removals has occurred annually. This is more than reported previously by Probst and Konisky (2001, Ch. 2), who did not include removal actions on federal facilities in their totals.

Based on records in CERCLIS,[8] 69% of removal actions were time-critical through the end of 2002. Removal actions are often responses to spills and other accidents (which are not sites in the usual sense of a long-standing contamination problem), so first responders discover many of these releases; others are reported by facility personnel to comply with statutory and NCP requirements. Other removal actions are taken at sites that EPA expects to eventually undergo remedial action on the NPL, but which could become significantly worse before the remedial action process reaches the action phase. As Figure 3.1 suggests, removal actions can take place at NPL sites (or sites that will eventually be placed on the NPL) at any time after discovery. Probst and Konisky report that most removal actions (76%) are taken at non-NPL sites, and the vast majority (>95%) are taken at sites that have only one or two removals (Probst and Konisky 2001, 17).

Because summary data on the size and scope of removal actions, or about the risk mitigation involved, are not available, estimates of the cost of removal actions can be used to provide some comparison to other Superfund responses. Of course, costs are not necessarily related to benefits, but this approach will at least provide some evidence that typical removal actions are not inconsequential. EPA's Office of Solid Waste and Emergency Response (OSWER) is in charge of conducting and supervising federal removal actions, which account for about one-fifth of federal Superfund expenditures (Probst and Konisky 2001, 12, 22). EPA's internal CERCLIS database contains expenditure information, which suggests that EPA expenditures averaged about $330,000 per removal action for 1999-2002. An alternative estimate can be calculated by dividing total EPA expenditures for removals in 1999 as reported by Probst and Konisky (2001, 12) ($317.8 million) by the number of removals accomplished that year (477) to obtain an average cost of about $660,000. This value would include some 'overhead' but not all.[9]

To partially adjust for the fact that these values do not include private PRP expenses, this calculation can be adjusted by the number of removals for which PRPs pay. Probst and Konisky (2001) indicate that PRPs lead approximately 18% of all removals. This suggests about 390 EPA-led removals in 1999, at an average cost of about $810,000.[10] This suggests that a rough estimate of the total federal cost of the average removal action, including overhead, is about $1 million. Unless private removals are systematically larger or more complex, which appears not to be the case, private costs would tend to be similar or lower.

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[7] Data obtained from EPA's internal CERCLIS database on February 4, 2004. A small number (<3%) of the sites in this database are double-counted due to changing designations. The value above is 97% of the values reported in the database. Note: These values will be updated in the final version of the report.

[8] Not all CERCLIS data used in this study is available through the online CERCLIS query. Some CERCLIS data must be accessed through EPA.

[9] Using the number of removals in 1999 that Probst and Konisky found, 310, this average is about $1 million (2001, 22).

[10] This percentage may be inaccurate to apply to the larger internal CERCLIS count of removal actions. Adjusting the number of removals that Probst and Konisky found (310) by this percentage yields an average cost of about $1.3 million.

Case Study: LCP Chemicals Georgia

The LCP Chemicals Georgia NPL site is in the small city of Brunswick, Georgia, near the Turtle River Estuary.TP [1]PT The site comprises 550 acres, most of which is tidal marsh, and is contaminated with mercury, lead, polychlorinated biphenyls (PCBs), and semi-volatile organic compounds (SVOCs). The magnitude of the contamination at this site is evidenced by the fact that although EPA has recovered over 200 tons of mercury from the site, much more remains to be dealt with (Baker 1997). High mercury and PCB levels in the site's aquatic life have resulted in a ban on commercial fishing and a seafood consumption advisory for much of the estuary. Sampling of the water, sediment, and biota at and near the site confirmed that mercury and other hazardous substances were bio-available in species such as fish, fiddler crabs, and oysters, and that the conversion of mercury into the most harmful form (methyl mercury) was occurring (Matta, Gray, and Francendese 1998). Within four miles of the site, over 32,000 people rely on ground water for drinking and other uses (of which about 5,000 use private wells), and monitoring is beginning to show ground water contamination. Thus, without a Superfund response, many people would have been potentially exposed to hazardous substances from this site. In addition, the site was insecure; holes in a perimeter fence allowed relatively easy access to the site, making exposure more likely.

The site was originally operated as a petroleum refinery, and was subsequently used for various industrial processes, the most important of which was a chlor-alkali plant to manufacture products such as chlorine gas, sodium hydroxide, hydrogen gas, hydrochloric acid, and sodium hypochlorite (bleach). Allied Signal operated the facility from 1955 to 1979, during which time many hundred tons of mercury-contaminated sludge were dumped in surface impoundments next to the tidal marsh. LCP Chemicals operated the facility until 1994, when state and federal officials shut the plant down.

The managers of LCP Chemicals had little regard for worker health, the environment, or the law. When EPA arrived at the site in the mid-1990s, they found pools of mercury inside buildings and oil refinery wastes laced with PCBs seeping into the marsh in several places. In its 1999 case against three former LCP Chemicals managers, the U.S. government claimed that "[c]ompany officials had illegally blocked the windows and doors to a lower floor of a production building to store [caustic wastewater] because they knew the company's water treatment system was not adequate." The three LCP officials were convicted of endangering plant employees and conspiring to violate the Clean Water Act (CWA) as well as CERCLA. In 1999, several LCP managers were convicted and sentenced to prison terms, including the longest sentence handed down for environmental crimes up to that time (nine years).

TP[1]PT Sources:

Baker, S. (1997). *A Toxic Legacy*. UPublic HealthU. **Fall**. www.whsc.emory.edu/_pubs/ph/phfall97/toxic.html.

Matta, M., G. Gray, et al. (1998). ULCP Chemical Site Monitoring StudyU. Silver Spring, MD, NOAA National Ocean Service Office of Response and Restoration, August.

Scogin, G.E. (1994) Action Memorandum: Documentation for an Enforcement-lead Removal Action at the LCP Chemicals Site in Brunswick, Glynn County, GA. Atlanta, GA: U.S. Environmental Protection Agency Region IV. p. 11.

Various documents available on the Internet in August-September 2004. These sources include the following: EPA's Fact Sheet, updated 5-11-04, www.epa.gov/region4/waste/npl/nplga/lcpincga.htm; EPA's NPL Site Narrative, June 1996, www.epa.gov/superfund/sites/npl/nar1458.htm; T. Dickson, "Corporate Pollution Trial Begins," *Savannah NOW*, 1/13/99, www.savannahnow.com; EPA's Remedial Investigation Fact Sheet, June 2002, http://www.epa.gov/region4/waste/npl/nplga/lcpjune02fs.pdf; "Official Receives Record Prison Term for Environmental Law Violation," 6/18/99, www.edie.net/news/Archive/1305.html; and, "Guidelines for Eating Fish from Georgia Waters: 2004 Update," Georgia Department of Natural Resources, www.dnr.state.ga.us/dnr/environ/gaenviron_files/fishadvs_files/fcg_2004.pdf. Further information is also available at www.glynnenvironmental.org

Case Study: LCP Chemicals Georgia (cont.)

After the plant closed in 1994, the state of Georgia designated LCP as the state's highest priority site and requested that EPA take immediate action and place it on the NPL. The resulting sequence of events is a good illustration of how removal and remedial actions are often coordinated at NPL sites, how CERCLA and other laws act in concert to protect human health and the environment, and how considerable ecological damage can be reversed (without ever being measured) as an additional benefit to the health risk reductions that motivate the response actions.

The most pressing concerns at the site included the threat of chlorine gas release and the flow of contamination into the marsh inhabited by endangered species. In 1994, EPA determined that the site presented an imminent and substantial endangerment to public health, welfare, or the environment and ordered the parties responsible for the contamination to remove contaminated soils and sediments from the site and dispose of them appropriately. The removal action at the site was completed in 1999; it excavated the vast majority of on-site soils and waste piles. Over 132,000 tons of hazardous waste were removed from the site and disposed of appropriately. Thirteen acres of contaminated sediment were excavated from the marsh.

This rapid response greatly reduced the environmental and health risks at the LCP Chemicals Georgia site. The removal action carried out at the site resulted in lowered levels of PCBs and mercury in the site's aquatic species. For instance, before the removal action, the Georgia Department of Natural Resources advised against consuming some locally caught fish (e.g. red drum). Data collected after the removal action showed that it is now safe to eat fish once a week, although shellfish and some fish species are still unsafe for consumption.

Currently (in late 2004), EPA is assessing the need for further cleanup at the site. The Remedial Investigation / Feasibility Studies for the ground water operable unit and the upland soil and marsh operable unit are nearing completion, after which EPA will decide on final site remedies. Some of the data that would be needed to estimate risk reductions will become accessible at that time. This investigation is also exposing new concerns, such as a recently discovered pool of mercury beneath a sandstone layer at the site, as well as a caustic brine pool, both of which illustrate how complex many NPL sites are and why detailed investigation is often needed.

In this case, only CERCLA provided the legal authority to EPA to force the firms that polluted the site to clean it up; however, this had the effect of advancing the goals of numerous environmental laws, like the CWA. Without the existence of CERCLA (the policy case considered in the SBA), it might have been possible to shut LCP Chemicals down, but the hundreds of tons of contaminants on the site would have remained and continued to leak into the estuary and nearby ground water, increasing the risks to human health and the environment.

None of the ecological improvements at this site has been quantified or recorded, largely because there is no statutory or regulatory reason to do so. Thus, this case illustrates how the ecological benefits estimated in Chapter 5 may be a significant underestimate, because the data used in that chapter ignores reversals of injuries to natural resources (and the avoidance of future natural resource injuries) due to Superfund responses.

This site also illustrates some of the challenges left for the nation in dealing with uncontrolled releases of hazardous substances. Essentially the entire marsh, and possibly a significant portion of Turtle River, is contaminated with hazardous metals that will not degrade or disperse for many decades. Thus, the only ways to eliminate the contamination are to either clean an enormous amount of soil and sediment, or to replace it. Both options would essentially destroy the marsh in order to render it harmless, and would also be very expensive. Other alternatives, which would essentially cap the contaminants, would probably not permit the continued existence of marshlands at this location and could be quite unattractive. With such challenging problems, it is no surprise that sites like LCP Chemicals tend not to be resolved quickly and are accumulating on the NPL.

This case study also illustrates how the EPA responds to challenging problems of hazardous substance contamination with innovative approaches. An experimental phytoremediation project was approved by EPA in November 2003 that will locally suppress the ground water table and prevent seepage of contaminated ground water and staining of sediments.

<u>The Remedial Action Pipeline</u>

Overview

The NCP gives EPA the authority to undertake larger, more complex responses to actual or potential uncontrolled releases of hazardous substances through the remedial action program. Remedial actions also tend to fulfill the Congressional mandate in SARA to seek permanent solutions to releases at sites where both removal and remedial actions occur – this can be a major distinction. The removal action(s) may temporarily interrupt an exposure pathway, but leave the contamination in place or only remove some of the contamination. The remedial action then treats or isolates the hazardous substance, thereby providing a long-term solution. Often, soil or ground water contamination is dealt with through remedial actions because these pathways may not present an imminent risk (which would trigger a removal action) or are expensive and time-consuming to address (thus falling outside of the limitations of removal actions). The RSR Smelter case study on page 4-21, the Butterworth #2 case study on page 2-14, and the LCP Chemicals case study on page 3-10 all illustrate how removal and remedial actions are designed and implemented together at individual sites.

Sites must be on the NPL for EPA to have the authority to conduct a remedial action and for the liability scheme to be invoked against potentially responsible parties. Thus, NPL sites are the most well-known and most expensive part of the Superfund program, and are often what is being referred to when terms like “Superfund cleanups” and “Superfund sites” are used casually. In recent years, more than two-thirds of all remedial actions have been paid for by PRPs, who also pay for remedial action at VCP sites (Probst et al. 1995, 33). The cost of individual NPL remedial actions varies a great deal, but estimates of average costs for individual sites (excluding overhead) fall in a fairly narrow range of about $15-$30 million, with a best subjective estimate of about $25 million; this is around 25 times the cost of a removal (Probst et al. 1995, 33; Hamilton and Viscusi 1999, 111, 119). However, some individual remedial actions involve hundreds of millions of dollars of effort, so adequate preparation and design is often a complex task in itself. Understanding how the NPL pipeline (shown in the bottom right of Figure 3.1) works is important to understanding how remedial action creates benefits; therefore, the following sections go through each step.

Remedial Investigation/Feasibility Study (RI/FS)

In the Superfund program the remedial investigation (RI) serves as the mechanism for collecting data to characterize site conditions, determine the nature of the hazardous substances on the site, assess risk to human health and the environment, and conduct treatability testing to evaluate the potential performance and cost of the treatment technologies that are being considered. The feasibility study (FS) is the mechanism for the development, screening, and detailed evaluation of alternative remedial actions. Because the RI of the site informs the FS of potential remedies, and the FS affects the data needs of the RI, they are performed concurrently. The RI involves extensive data collection and analysis designed to characterize the scope of the problems and the potential threats to human health and the environment. Potential sources of contamination, the types of contaminants, affected media, release mechanisms, potential contaminant pathways, and actual and potential receptors are identified and modeled. During this phase a site may be broken into smaller segments called “operable units” (OUs). Each of these site segments may require a separate remedial action to mitigate the contamination at the site.

During the RI, the nature and extent of the contamination is defined, and the risks associated with human health and the environment are mapped out in the baseline risk assessment (BLRA). The BLRA is a crucial document in that it is the most complete statement of the risks associated with the site. While BLRAs are available publicly at regional EPA offices, they are typically not available electronically on the Internet and information from them is not compiled in any single database or other resource. Thus, BLRAs are not readily accessible to researchers, nor is detailed information in BLRAs available in any centralized location. The most accessible source for information from a BLRA is the Record of Decision (ROD) that is issued for each NPL site. In general, RODs are readily accessible (most are on the Internet); however, RODs only contain the summarized results of the BLRA. Some prior studies of the Superfund program have evaluated sites based on BLRA data, or on BLRA summaries from RODs (Walker, Sadowitz, and Graham 1995; Hamilton and Viscusi 1999).[11] However, a key issue, discussed further below, is that reduced risks or reduced exposures resulting from removal actions at NPL sites are often not represented in BLRAs, and practice appears to vary from site to site. Thus, the total risk reductions at NPL sites may be underestimated by studies based on BLRA or ROD data because risk reductions due to removal actions at these NPL sites are likely to be ignored.

The FS is used to compare the advantages and disadvantages of possible remedies developed for the site. The goals of the RI are refined through the FS process. Multiple remedy scenarios are studied through the FS to inform the selection of the remedy. Each remedial alternative is examined through the following criteria in order to select the best remedy:

- Protection of human health and the environment, based on site-specific risk assessment
- Compliance with applicable or relevant and appropriate requirements (ARARs), such as ground water standards
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume of hazardous substances
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

Selection of Remedy

The FS identifies the best response options; EPA then develops a proposed plan and solicits public input. With input from the public, EPA next selects a remedy and produces a Record of Decision (ROD). The ROD will document the remedy, support the decision, and develop performance standards or goals for the site (or OU) under consideration. The ROD will also provide a plan for the site's remedial action as well as document the risks to human health and the environment. Note that these risk assessments evaluate risks to the maximally exposed individual, not the mean risks or other more typical value that would be appropriate for calculating benefits (Viscusi 1997). Thus, even if it were available, this data would be of only

[11] Hamilton and Viscusi (1999) go beyond the information in the RODs they examine to conduct site-specific risk assessments, but their work still relies critically on the information contained in RODs.

limited use in a benefits study. However, many RODs are readily accessible in a single location on the EPA website (http://www.epa.gov/superfund/sites/rods/index.htm).

For some NPL sites, ARARs are the most stringent requirements and these largely determine the remedy (Walker, Sadowitz, and Graham 1995). In some cases ARARs are state standards. This is why they are shown separately in Figure 3.1. See the Butterworth #2 case study on page 2-14 for an example of how ARARs can play a role in the NPL remedial action process.

Remedial Design and Remedial Action
The remedial design (RD) phase is when the engineering plan for the site is determined. Specific technical requirements are designed to conduct the remedial action. This activity is very similar to conducting any technical engineering project: plans and specifications are prepared, permits and approvals are obtained, and cost estimates are prepared. In the remedial action (RA) phase, the plans developed during the RD are implemented (constructed) and the actual cleanup process of the remedial action begins. The remedy must conform to the specifications outlined in the ROD. Projects vary in complexity, including soil excavation, encapsulation, or the use of complex subsurface systems to extract or negate the effects of the contamination.

After the RA is complete, the site has been cleaned up – removal and remedial action(s) have eliminated immediate risks, although ongoing operation of remedial action technologies may be needed to deal with some long-term risks. In cases where this is true for all operable units at a site, the site may be designated as "construction complete" (CC).[12] In any case, there may still be important post-construction activities remaining.

Institutional controls are used to supplement Superfund remedies when residual contamination restricts the unimpeded use of a site or ground water aquifer. Examples include easements, zoning restrictions, use restrictions, and deed notices. Institutional controls are implemented during or immediately following remedy implementation, and they should be maintained as long as needed to prevent human or environmental exposure or to protect the remedy.

Post-Construction
<u>Overview</u>
Many sites on the NPL require long-term care after construction of the remedy is completed. The goal of the post-construction phase is to ensure that Superfund response actions provide for the long-term protection of human health and the environment. Specific activities include the following:

The operation and maintenance (O&M) phase includes actions taken to ensure that Superfund remedies perform as intended, including maintaining engineered containment structures (e.g., landfill covers), and operating ground water restoration systems. Ground water restoration generally requires active management over many years to ensure effective and efficient operations, and to ensure that cleanup goals are achieved. In addition, it may be necessary to

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[12] Usually, the term "construction complete" refers to all NPL sites that have reached either this status or deletion, and will be used in this way here.

take actions after remedy construction has been completed to ensure that institutional controls continue to remain in place.

For many NPL sites, deletion from the NPL is the last stage in the pipeline. Sites can be deleted from the NPL once all response actions are completed, all cleanup goals are achieved, and no further response is needed. Some deleted NPL sites, however, may still have hazardous substances present in concentrations and locations beyond levels that would allow for unrestricted use and unrestricted exposure. These sites may require operation and maintenance actions and Five-Year Reviews for some period of time.

Provisions of CERCLA and EPA's policy require that Five-Year Reviews occur when hazardous substances remain on sites above levels that would allow for unrestricted use and unrestricted exposure. Five-Year Reviews provide an opportunity to evaluate the implementation and performance of the remedy to determine whether the site remains protective of human health and the environment. For instance, a site that has had a barrier installed, like a cap, may be reviewed to look for evidence that the barrier is still functioning. Reviews are completed every five years as long as future uses of the site are restricted.

<u>Community Involvement</u>

As part of the NPL process, EPA involves the public at various stages of the remedial process. The amount of information flow and public interaction depends greatly on the level of complexity of the site. Public comment periods and formal responses to public comments are conducted at all NPL sites and at many removals.

EPA also provides additional services to the public beyond those required for the administrative record. In 1986 Congress established the Technical Assistance Grant (TAG) program to help communities understand the technical aspects of hazardous substances (U.S. Environmental Protection Agency 2000; Office of Solid Waste and Emergency Response 1998a). The grant provides funds for a community affected by an NPL site to hire independent technical advisors who can help them understand the information and recommendations related to the site(s) in their community. TAGs are available to communities where there is a proposed or listed NPL site. TAGs are available only to community organizations (not governments), and recipients must live near the site and have their health, economic wellbeing, or enjoyment of the environment threatened.

<u>State Roles</u>

CERCLA provides for a substantial role for states in the Superfund program. Among the provisions involving states are requirements for a state to share costs for remedial actions (typically 10%), substantial and meaningful involvement in remedy selection, and the ability to carry out response actions. Specifically, CERCLA authorizes the federal government to enter into cooperative agreements with states and Indian tribes to carry out response activities consistent with the National Contingency Plan (CERCLA as amended by SARA, Section 104(d)(1)). EPA's regulations also authorize funding for building state programs to carry out those activities and to develop their own response programs. Since 1987, Superfund State Cooperative Agreements have totaled over $3 billion, including over $300 million for building and maintaining state programs. Consequently, states have performed a significant number of CERCLA site assessments, along with a much smaller number of RI/FSs, RDs, and RAs.[13]

State response programs have grown in scope, capability, and sophistication, particularly over the last decade, and have provided an alternative to Superfund for many sites. Some states have developed the legal and technical capacities to deal with complex sites similar to those that typically end up on the NPL (General Accounting Office 1998a). States have been especially active in developing VCPs and programs to support brownfields redevelopment. These developments have undoubtedly led to benefits associated with the cleanup and redevelopment of thousands of non-NPL sites across the country. In the context of analyzing Superfund benefits, federal funding to build and maintain state programs means that some of these benefits should be attributed to Superfund even though the majority of sites in response action programs fall under state authorities and programs. However, at this point, data are not available to support a definitive analysis of either those benefits or the portion that would be attributable to funding under CERCLA.[14] In addition, the problems associated with the type and accessibility of federal removal and remediation actions also occur in the state programs. In the context of attempting to understand the benefits of the national Superfund program through actions by the states, these data problems are compounded by the fact that state activities are not compiled in any single place. Although data are not available to support a definitive estimate of the magnitude of the benefits of state Superfund programs, the next section uses available data to estimate the fraction of these benefits that should be attributed to CERCLA and SARA.

Quantifying Responses

The current study present estimates of some of the benefits of remedial actions at NPL sites, omitting entirely the benefits of other Superfund responses (e.g., removals and state actions) due to the lack of relevant data (see Chapters 4 and 5). This approach will thus underestimate the benefits of the Superfund program as a whole. While it may not be possible to definitively know the magnitude of the resulting underestimate, it *is* possible to gain some insight into whether this underestimate is large or small by quantifying all of the response actions.

<u>Responses Associated with the Remedial Process</u>

EPA provides technical and oversight support for many non-NPL sites, which creates a potential benefit that is not quantified here. As of the end of FY 2003, EPA had performed preliminary assessments (PA) at almost 44,000 sites and proposed or finalized 1,572 of them on the NPL. Thus, about 3% of all sites that are listed in CERCLIS for possible evaluation under the Superfund program are placed on the NPL. Where the PA/SI indicated that no federal remedial action would be taken, the sites were placed in the Superfund archive list. Thus, there are over 40,000 sites in the nation that at one time or another were suspected of having hazardous substances on them where EPA has determined no Superfund remedial action is needed. This provides the benefit of reducing uncertainty for the community and potential developers in

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[13] In most circumstances, funding for removals from the CERCLA trust fund is reserved to EPA.

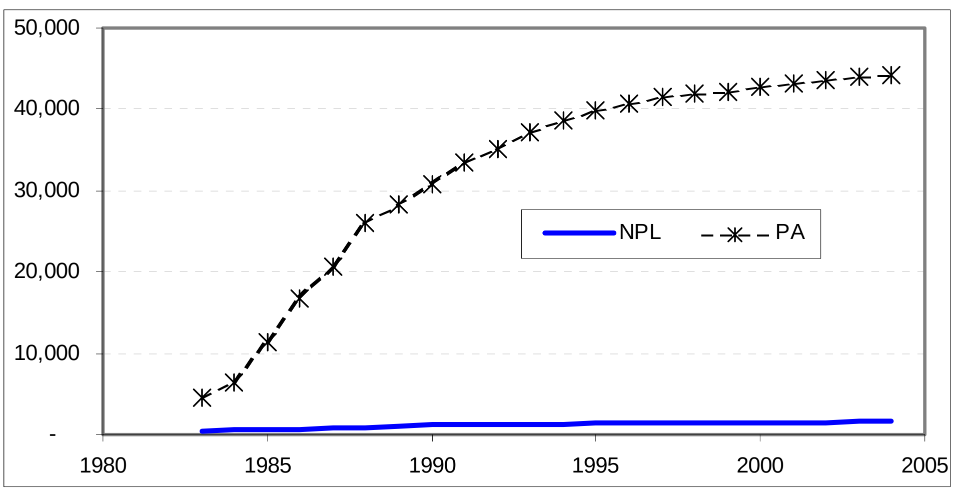
[14] The most detailed review of state response programs provides considerable discussion of the programs and quantifies the level of activity, but it does not provide sufficient information to develop a reliable estimate of the economic benefits or the amount leveraged by Superfund cooperative agreements (Environmental Law Institute 2002).

relation to those 40,000 sites. The latter effect can make previously used property available for use without concerns about liability, enabling new commercial or industrial activities to occur. This may lessen the need for additional conversion of agricultural or wild lands into developed property.

Figure 3.2 shows the cumulative number of NPL sites and PAs for 1980 – 2004. For this figure, and for most of the current study, "NPL sites" are defined as sites that have ever been on the NPL, or those that have been proposed or listed. This cumulative value is shown in the solid lower line in the figure. At the end of FY 2003, the total number of NPL sites on the NPL was 1,572. Twenty of these sites are in U.S. Territories (e.g., Puerto Rico and Guam) and essentially no data are available to describe them; therefore, these are not included in this analysis, which leaves a cumulative total of 1,552 NPL sites analyzed for calculating benefits. The results in Chapters 4 and 5 are based entirely on data for these 1,552 NPL sites.

This figure shows that more than half of all PAs were performed in the first ten years of the Superfund Program. Over the last several years an average of over 200 sites per year received PAs. To the degree that this work continues to reduce the uncertainty associated with potential releases, the Superfund program continues to provide a benefit by screening sites. This benefit might be placed in the *amenities* category (defined in Chapter 1) to the degree that perceived health risks decline with the reduced uncertainty, and in the *materials* category (defined in Chapter 1) to the degree that commercial property is made usable by the reduced uncertainty.

Figure 3.2. Cumulative NPL Sites and Preliminary Assessments



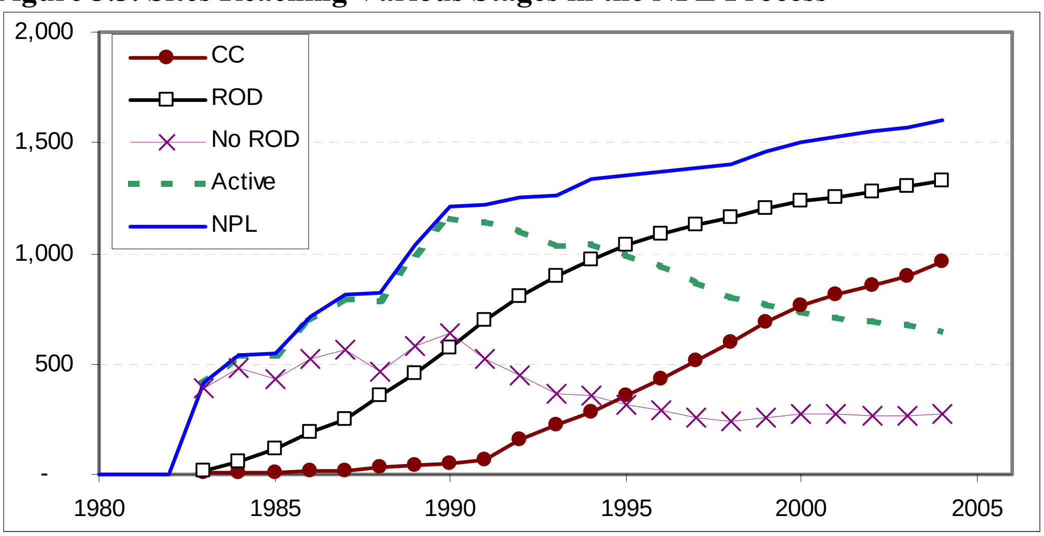
Note: "NPL" refers to all sites that have been proposed, final, and deleted from the NPL.
Source: CERCLIS

Progress with the NPL itself is described by Figure 3.3, which also shows the cumulative number of NPL sites, as well as the cumulative number of NPL sites for which RODs have been issued, and the number that have reached either construction complete or deleted status (CC). The plot of RODs issued shows how many NPL sites have plans for remedial action. The plot of CC sites shows how many have reached the final stages of the NPL process and for which the releases have been dealt with (except for ongoing O&M). A category of *active* sites is defined as those sites that have been proposed or listed on the NPL, but for which plans for remedial action have not yet been made. The number of *active* sites shown in Figure 3.3 is calculated by subtracting the number of CC sites from the total NPL.

Figure 3.3 shows that the NPL grew quickly during its first few years of existence. From zero sites in 1980 – 1982 (CERCLA was signed into law on December 31, 1980), the number of NPL sites grew suddenly to over 400 in 1983.[15] By 1987, more than half of the current NPL had already been proposed or made final. Over the last ten years, annual additions to the NPL averaged about 30 sites.

Through the early 1990s, over 1,000 sites had RODs issued.[16] This pace slowed down around 1995, and over the last ten years, approximately 40 RODs have been issued annually. At the end of FY2003, 83% of all sites on the NPL have at least one ROD issued. Sites with more than one OU may have different RODs issued for each one. The values for RODs in Figure 3.3 ignores multiple OUs and represents the number of NPL sites for which RODs have been issued, not the total number of RODs (which is higher). The annual values for ROD sites in Figure 3.3 are used in Chapter 4 to determine the dates at which benefits are assumed to occur. Chapter 4 also contains the discussion of why these dates are used.

Figure 3.3. Sites Reaching Various Stages in the NPL Process



Note: "NPL" refers to all sites that have been proposed, final, and deleted from the NPL. "ROD" values are the number of sites for which a Record of Decision has been issued. CC values are the number of sites that have reached construction complete or deleted status. 'Active' sites are those that are proposed or final only, not those that have reached construction complete or deleted status. "NO ROD" sites are those that have been proposed or listed, but for which a ROD has not yet been issued.
Source: CERCLIS

[15] Technically, the first group of NPL sites were identified on December 30, 1982, but for consistency of record-keeping, they are shown in 1983. In addition, there were a number of sites that were discovered before 1980 that were later added to the NPL, e.g. Love Canal.

[16] Because the NPL process is long and complex, deciding how to count Superfund responses at NPL sites is difficult. RODs are chosen because they are usually issued approximately halfway through the NPL pipeline (Probst and Konisky 2001, 51). In addition, RODs are a good approximation of the point at which much of the difference between perceived and actual risk at an NPL site is eliminated (see Chapter 5).

The pace of deletion was slow throughout the 1980s, due to several factors. First, technologies to address releases of contaminated substances were not well established, and it took some time for both EPA and industry to develop the capability to deal with the complex and often large contamination problems found at many NPL sites. Second, many NPL sites have significant ground water contamination, which can take a long time to deal with because of the massive volumes of contaminated media and the slow rate of effectiveness of some underground remedial action technologies.

For convenience, *deleted* and *construction complete* designations are combined in the designation "CC" shown in Figure 3.3. The start of the *construction complete* designation in 1993 is evident in the rise in the rate of sites reaching CC status. The annual increase in the number of sites reaching CC status has been fairly constant since then, averaging about 65 sites per year over the last decade. Because this is about twice the rate of sites entering the NPL, Figure 3.2 shows the NPL and CC curves have been converging for over a decade. At the end of FY 2003, 60% of all NPL sites had reached either *construction complete* or *deleted* status.

This progress is also evident in the *active* data. This includes Proposed or Final NPL sites, but excludes sites that have reached *construction complete* or *deleted* status.[17] They are *active* in the sense that there are on-site activities associated with risk assessment, remedy planning or remedy implementation. Through the early 1990s, the number of *active* sites is very close to the number of NPL sites, since few had been deleted. The number of *active* NPL sites peaked in 1990 at 1,162 sites, and has declined steadily since then (except for 1994). At the end of FY 2003, 643 NPL sites were *active*.

Sites that have been *proposed* or *listed*, but for which no ROD has been issued are labeled "No ROD" on Figure 3.3. The number of *No ROD* is approximately equal to the number of NPL sites in 1983 – 1984, but as plans for remedial action were developed, this value tended to become smaller than the total number of NPL sites after that. The number of *No ROD* sites peaked in1990 at about 638, or about half the number of NPL sites at the time. Since then, the number of *No ROD* sites has declined to under 300, or less than 20% of all sites that have ever been placed on the NPL. The meaning of these values is discussed in Chapter 4.

<u>Responses Associated with the Removal Process</u>

In order to understand whether the underestimate of the benefits of Superfund as a whole due to ignoring removal actions is large or small, it is necessary to understand how many response actions there have been, and when they occurred. Because CERCLA and SARA authorize response activities, all federal responses are assumed to be attributable to Superfund.

Information is available about each removal action in the Removal Site Evaluation (RSE) or Engineering Evaluation/Cost Analysis (EECA) prepared for each site. These documents are summarized in the Action Memorandum (AM) that serves as the official written record of the decision to conduct a removal action. However, these documents are not readily accessible to

[17] Important activities still continue at sites that have reached construction complete and deleted status, including operation & maintenance of remedial technologies and Five-Year Reviews.

researchers as they are not transferred into a centralized database and typically exist only as paper records stored at the various Regional EPA offices (Office of Emergency and Remedial Response 1990; Office of Solid Waste and Emergency Response 1990; Traceski 1994).

Data on removal actions were obtained from the CERCLIS database on November 26, 2003 for the fiscal years (FY) 1980 – 2002.[18] Very little information about removals is readily accessible. However, the total number of removals performed each year is available, and some cost information is available. By the end of 2003, EPA had undertaken 8,860 removal actions, averaging slightly over 435 annually during the last ten years.

Based on prior research and an evaluation of the CERCLIS database, most removal actions (between one-half and three-quarters) occur at non-NPL sites (Probst and Konisky 2001, 16-17).[19] Of those that do occur at non-federal NPL sites, 87% occur at sites where only one removal occurs, and about 10% occur at sites with two or three removals. A few NPL sites experience many removals (some sites have over ten) but these amount to a relatively small fraction (<3%).

Guidance on risk assessment and on conducting removal actions is silent on how removals should be represented in BLRAs (Office of Emergency and Remedial Response 1989; Office of Solid Waste and Emergency Response 1990, 1998; RCRA/CERCLA Division 1993; Traceski 1994, 1995). In practice, removal actions at NPL sites can be treated in different ways.[20] Removals that temporarily interrupt exposure pathways (e.g., fences) tend to be ignored because the statutory intent behind SARA for permanent solutions to uncontrolled releases of hazardous substances results in a remedy that will not necessarily make use of that temporary removal action. These removal actions are ignored when the baseline risk assessment (BLRA) is performed for the site as part of the RI/FS. If the number of these removal actions is added to the number of remedial actions, double-counting would occur.

However, some removal actions at NPL sites are more significant and may involve such steps as taking contaminated soil off-site to a disposal or incineration facility, which permanently and significantly changes the characteristics of the site. When BLRAs are performed for these sites, the post-removal condition of the site is evaluated in the BLRA, and the risks that the remedial action addresses are treated separately. For instance, a removal might take away and treat drums that are leaking, or are about to begin leaking hazardous substances, while a remedial action of the site would clean up the soil and ground water from the hazardous substances that had already leaked out. Thus, these two responses address two different goals of CERCLA and reduce two different types of risks. If the number of these removal actions were added to the number of remedial actions, double-counting would not occur.

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[18] Data for 2003 – 2004 are projected and estimated currently. In the final version of this report, actual values will be used.

[19] Probst and Konisky estimate the number of removal actions (non-federal sites only) in 1992 – 1999 as 2,053, of which about 495 (24%) occurred at non-federal NPL sites.

[20] The Superfund program has changed significantly since it was started, and the number of removal actions began to increase dramatically around 1990. This description is accurate for the program as it has existed for the last few years, but may be less accurate for removal actions that occurred before the mid-1990s.

Unfortunately, there are no quantitative data at present to distinguish between these scenarios. This is a limitation, but it does not affect the results in Chapters 4 and 5 because these chapters ignore removal actions entirely. The uncertainty associated with not knowing how to treat removal actions that occur at NPL sites affects only the consideration of the underestimate caused by ignoring removal actions in Chapters 4 and 5. The calculation of the number of Superfund responses given below assumes that all removal actions are not included in the BLRA. Therefore, each removal action is considered a separate response.

Quantifying State Responses
In order to understand if the underestimate of the benefits of Superfund as a whole due to ignoring state Superfund actions is large or small, it is necessary to understand how many state response actions there have been, when they occurred, and how many of them can be attributed to CERCLA and SARA. In general, fewer data are available for state activities than for federal activities, and the data that exist are less complete. Therefore the estimates in this section are likely to be more uncertain that those in the previous sections.

The number of response actions taken by state Superfund programs is considered first. Detailed data for multiple states are available from two sources that have conducted several studies of state Superfund programs.

The most recent study by the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) involved a survey sent to all states and territories, and received replies from 33 of them (Association of State and Territorial Solid Waste Management Officials 1998). Responses that summarized state programs were not accepted for data quality reasons, and instead only responses that documented each site individually were included. Some of the excluded states have large state Superfund programs, such as Michigan and Pennsylvania (Environmental Law Institute 2002). For 1993 – 1997, the ASTSWMO study reported that 33 states averaged 485 removals annually, and 1,597 remedial actions (all RA Completions) annually. This level of effort represents an 80% and 670% increase, respectively, over the levels found in a previous ASTSWMO study for 1980 – 1992 (271 and 207, respectively). The cumulative number of state removals for 1993 – 1997 was 2,303, and the total for state remedial actions was 7,584.[21] These values are for 33 states, excluding those that did not respond to the survey or did not provide sufficiently detailed data.

The Environmental Law Institute (ELI) has conducted several studies, also using a survey technique (Environmental Law Institute 1998, 2002). The results reported here are from the most recent study, which evaluated forty-four states. This study reported that state Superfund programs completed 4,5000 “cleanups” at non-NPL sites in 2000 (the total since these programs were begun is about 29,000. A further 15,700 cleanups were reported as being underway in 2000. These numbers are approximately the same as found in 1997.

However, since the early 1990s, many states have developed much more active state remedial action programs as well as voluntary cleanup programs (VCPs) to encourage and oversee private

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[21] The reporting period actually covers only 4 years and 9 months.

remedial action of releases. Enforcement actions (e.g., lawsuits against PRPs) also increase the spending on “state Superfund” sites. The 2002 ELI study finds that VCP cleanups account for almost half (45%) of state Superfund responses, but private spending is not estimated.

The number of cleanups reported by the ELI studies is greater than those reported by the ASTSWMO report. This difference may be partly explained by the larger number of states included in the ELI study. However, another factor is the difference in survey technique – the ASTSWMO study required respondents to provide data for each site and did not accept totals. The ELI study notes that definitions of “cleanup” vary from state to state and have changed over time for individual states (2002, 16). The ASTSWMO study methodology may have partially controlled for this effect. As a result, the number of state responses calculated below relies on the ASTSWMO estimates.

The ELI study also notes that states report a large number of sites that may require response actions in the future (2002, 15-16).[22] States reported about 23,000 sites “in need of attention,” although there is no information about the level of risk presented by these sites. Nonetheless, this large number suggests that although there may be a finite number of sites with uncontrolled releases (actual or potential) of hazardous substances, current levels of response activity could continue, or even increase, for some time.

The 2002 ELI study notes that the number of state cleanups reported in 2001 was approximately equal to the number in 1997, suggesting that it is reasonable to extrapolate the number of cleanups found by ASTSWMO for 1997 forward. There is no evidence that the number of state Superfund activities have declined significantly in the last few years, so the ASTSWMO estimates are extrapolated to 2004.

Budget information provides some insight into the size of state Superfund programs, and provides one basis of determining how many state response actions to attribute to CERCLA and SARA. The states are crucial to environmental protection in the United States. Combined, states spend about the same amount on environmental protection as the federal EPA’s budget; however, states also receive considerable federal grants and distinguishing the source of state expenditures is not always straightforward.[23] One study found that total state spending in 2000 to “develop and maintain a comprehensive hazardous waste management program (which could include remedial action of Superfund sites and addressing underground storage tanks)” was $1.4 billion (Brown 2001 table 3). Comparing these values with other data suggests that less than one percent of this amount is actually devoted to remedial actions at NPL sites, which seems reasonable given that the NPL is a federal program (Congressional Budget Office 1994). Probst and Konisky (2001, 96) document an ongoing commitment of state resources (that is, funds other

[22] Probst and Konsisky (2001, 28-30) make a similar observation about the EPA’s removal actions, their number appears to be limited by resources to deal with them, not the number that could use attention.

[23] Brown (2001) gives a higher value in his text, but this calculation includes expenditures associated with activities that are the responsibility of agencies other than the state analogs for the EPA (e.g. forestry, and fish and wildlife). The sum of state expenditures given by Brown for state activities in 2000 is similar to those EPA is responsible for (Table 3: Drinking Water, Water Quality, Hazardous Waste, Pesticides Control, Solid Waste, and Air Quality), and is approximately $6.6 billion. This amount includes all sources of state expenditures, including EPA grants and other federal monies.

than those from the federal government) to address uncontrolled releases of less than $200 million annually for nine states with significant numbers of releases and almost half the nation's population (CA, FL, MA, MO, NJ, NY, OH, PA, TX). This value can be compared with the estimates of total state Superfund expenditures reported by ELI, which average about $500 million annually for 1992 – 2000, although it is not clear how much of this money comes from the federal government (Environmental Law Institute 2002, 18-28). States report highly varied levels of federal support for their Superfund activities, from 2%-90% (18).

Overall, however, approximately one quarter of state environmental expenditures come from the federal government (Brown 2001). Lacking any more definitive value, this study will attribute 25% of state Superfund responses on the basis of funding. This approach ignores the potential that Superfund has any role in causing privately financed responses under state VCP programs because private expenditures are *not* included in the state budget figures discussed above.

In addition to funding support, Superfund supports state activities in other ways. The Superfund statutes, CERLA and SARA, provide the states with authority and credibility in managing releases (King 2002; National Governor's Association 2003; National Conference of State Legislatures 2004). The New Hampshire Commissioner of the Department of Environmental Services, representing the Environmental Council of the States, recently testified: "…with respect to sites not on the NPL … comprising a universe far greater than the NPL, … the success of many state programs in addressing these sites has been reliant on the present federal liability structure" (2000). State responses also benefit from the research and development activities sponsored by the Superfund program to improve the technologies and practices for the management of hazardous substances. Thus, the number of state Superfund responses that can be attributable to CERCLA and SARA may be higher than would be indicated by the amount of funding support alone (Science Advisory Board 1990). However, there is no obvious method to quantify this effect, so it is ignored.

<u>Comparing Superfund Responses</u>

The analysis discussed above permits a calculation of the total number of response activities that can be attributed to the Superfund program. This value can be used to help consider whether estimates of benefits in Chapters 4 and 5, which ignore some classes of Superfund response actions, are underestimates by small or large margins.

Table 3.2 presents the number of total responses to uncontrolled releases of hazardous substances in the United States for the period 1980 – 2004, and the number that can be attributed to CERLCA and SARA (i.e. Superfund). As discussed above, the number of EPA remedial actions is equal to the number of RODs found in the CERCLIS database. This amounts to 1,326 actions. The number of EPA removal actions is equal to the number of response actions found in the CERCLIS database. This amounts to 7,798 actions. The total number of state actions (both removal and remedial actions) is taken from the ASTSWMO studies for 1980-1997, which reports only on 33 states. The 2002 ELI report contains data that shows no significant change in the number of state response from 1997 to 2001, and there is no more recent data to suggest significant changes in state-level response activity. Therefore, the trend reported by ASTSWMO for 1992 – 1997 is extrapolated through 2004, yielding 9,345 state removal actions and 21,649 state remedial actions for 1980 – 2004. These values do *not* address the risk addressed by any of these response actions, only the number of actions.

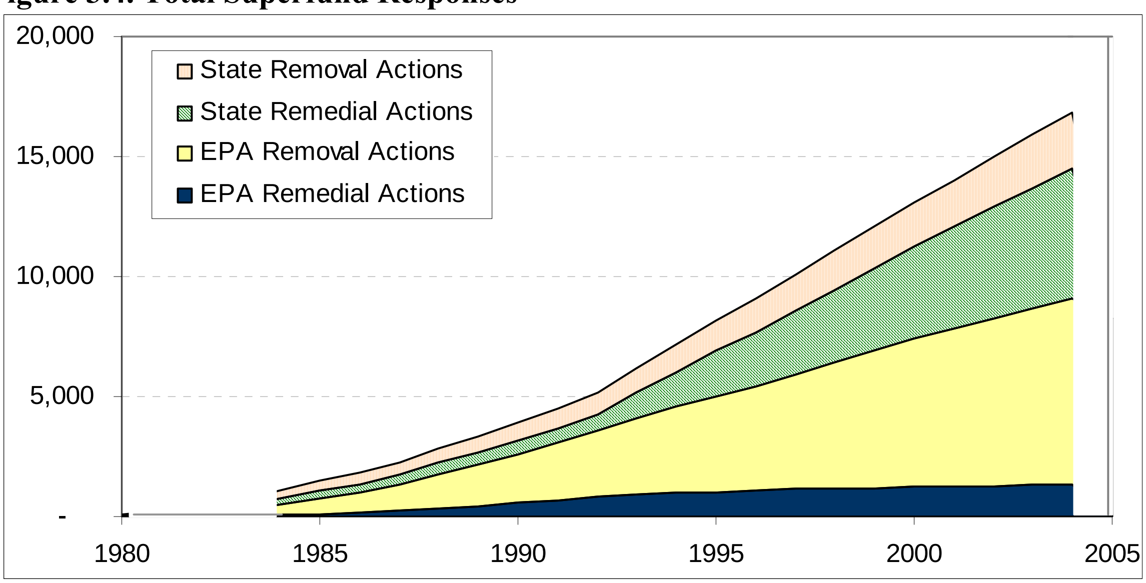
The EPA response actions are obviously attributable to CERCLA and SARA, but there is no clear, objective method to determine how many state response actions should be attributed. Based on the discussion above concerning the average percentage of state environmental expenditures provided by federal sources, 25% of state actions are attributed to CERCLA and SARA in Table 3.2. Thus, the total number of state responses that are attributable to Superfund for 1980 – 2004 is 7,748. These values are presented graphically in Figure 3.4. These values address the number of actions, *not* the risk addressed by any of these response actions. These values are *not* used in any of the subsequent chapters to calculate benefits.

Table 3.2. Total Responses and Total Superfund Responses, 1980 – 2004

Response type	Total Responses	Attributable to Superfund**	Superfund Responses
EPA remedial action	1,326	1.0	1,326 (8%)
EPA removal	7,798	1.0	7,798 (46%)
State remedial action*	9,345	0.25	2,336 (14%%)
State removal*	21,649	0.25	5,412 (32%)
TOTAL	40,118		16,872

* Uses data for 33 states and assumes no state response actions for 1998 – 2004.
** Assumes only 25% of state actions are attributable to Superfund, based on federal funding to states.
Sources: See text.

Figure 3.4. Total Superfund Responses



Note: See Table 3.2.

This analysis suggests that of all Superfund responses for 1980 – 2004, remedial actions at NPL sites represent only 10% of the total, assuming no state response actions after 1997. The alternative assumption implies that remedial actions at NPL sites represent only about 8% of all Superfund response actions. If data for state response actions in all 50 states were available, these percentages would likely be even lower.

Thus, remedial actions at NPL sites make up only a small fraction of all Superfund response actions. This suggests that the estimates of benefits in Chapters 4 and 5, which are based on analyses of only the NPL, may be non-trivial. Of course, the size of any underestimate depends on the risk reduction (or other benefits, like amenities improvement) that non-NPL response actions create, about which there is very little data.

Characterizing NPL Sites

The third part of this chapter characterizes NPL sites. Due to a lack of data accessibility, it is not feasible to characterize NPL sites according to risk. However, several other important features of NPL sites are available to characterize NPL sites, including area, nearby population, the number of homes nearby, duration of time from proposal to CC, and location within or outside of a Metropolitan Statistical Area (MSA). These features are important to the analysis presented in Chapters 4 and 5. For the purposes of this study, and based on the existing literature, a distance of 2.5 miles from the boundary of the site will be used to define "nearby." Chapter 4 contains a discussion of this assumption and includes a sensitivity analysis of it. The designation of within or outside an MSA allows a rough division between urban/suburban sites and rural sites.

In order to know whether the benefits transfer analyses in Chapters 4 and 5 are reliable, several groupings of NPL sites are created in order to compare the "study case" (the subject of a prior valuation study) with the "policy case" (the subject of the current study). For the analysis in Chapter 4, the policy case will be all the NPL sites that have had a ROD issued by the end of FY 2004; this group is labeled ROD. The analysis of these sites is aided by creating a group, MROD, consisting of those ROD sites that are located within an MSA. The analysis in Chapter 4 is based on a set of prior studies that examined the changes in home prices near a total of 24 NPL sites and 16 non-NPL hazardous waste sites. These 24 NPL sites are placed into a group labeled "Property" in Table 3.3.[24]

The policy cases for the different sections of Chapter 5 vary from effect to effect. For instance, for cancer, the study cases are the 150 NPL "risk sites" that Hamilton and Viscusi (1999) examined, and this group of NPL sites is labeled "HV" in Table 3.3.[25]

Finally, federally-owned NPL sites (e.g., former military bases and Department of Energy sites) are often analyzed separately from others; these may be different from other sites in terms of size and population, which are important in this analysis. To study these sites, a group "Federal" is designated in Table 3.3.

[24] For a list of these sites, see Table 4.3.

[25] NOTE: By agreement with EPA's Science Advisory Board Staff, the health effect-by-effect analysis has *not* been conducted for this draft, only proposed. This discussion of the cancer benefits transfer analysis and the related study and policy cases is meant to be illustrative only. If it and the other health effect-by-effect analyses are approved, several other NPL site groups will likely be designated.

Table 3.3. Definitions of NPL Site Groups

Group name	Definition
NPL	All sites that are proposed, final, or deleted from the NPL through the end of FY 2004
ROD	All NPL sites for which a ROD has been issued through the end of FY 2004
MROD	ROD sites that are located within a Metropolitan Statistical Area (MSA)
Property	All NPL sites that are included in the property value studies used in Chapter 5
HV	The 150 "risk sites" used in Hamilton and Viscusi (1999).
Federal	All federal NPL sites

Data

Data with which to characterize these sites were collected from CERCLIS and from the U.S. Census for 1980, 1990, and 2000. ESRI's ArcView 3.2 geographic information system (GIS) software and its programming language, Avenue, were used to create algorithms to process the census data. These estimates were only calculated for the 50 U.S. states and the District of Columbia; sites in the U.S. territories were excluded. This section describes how these data were handled.

Census data on population and residences are available at several levels of detail, the most highly resolved (spatially) being the census block. Census blocks are combined first into larger census block groups and then into even larger census tracts. Census tracts contain approximately 4000 people. The differences in the sizes of these areas are shown in Table 3.4, which gives the mean and median values for all census blocks, census block groups, and census tracts that contain NPL sites. These area data are highly skewed – the data is bounded on the left by zero but includes some very large areas located in places with sparse population. The mean area of census blocks that contain NPL sites is more than an order of magnitude smaller than the mean area of census tracts that contain NPL sites. The difference between medians is larger, by a factor of fifty.

Table 3.4. Census areas with NPL sites (square miles)

Census Area Definition	Mean Area	Median Area
Block	2.0	0.24
Block Group	36	4.3
Tract	74	10

Census 1990 and 2000 population data were obtained at the block level and housing data at the block group level. 1980 data were queried at the county level, which is even larger than the census tract level.[26] Blocks and block groups are polygons that are often bounded by streets and other physical features, but do not have any relationship to NPL site boundaries or the distance rings of interest for this study.

Defining the site boundary is an important issue in this analysis. The boundaries for NPL sites (i.e., the extent of the releases) do *not* generally correspond to property boundaries, and some mining or ground water sites can cover very large areas. Most of the area included within the boundaries of a ground water site generally does not have hazardous substances at or near the

[26] The 1980 data was used for establishing population growth trends only. See Chapter 4.

ground surface, but there may be a plume of contamination in the ground water underlying the property. Similarly, mining areas and former military bases may have several “hot spots” that contain significant concentrations of contamination but cover only a small percentage of the entire area of the site as it is defined by EPA. Some mining sites, though, especially those where smelters operated, do have extensive areas of surface level contamination. These larger site types can have residences or even entire towns located within them.

The CERCLIS database contains a set of coordinates (latitude and longitude) that defines the location of each NPL site.[27] Site boundary data is not available. Those coordinates are assumed to be at the centroid of the site, and an ‘equivalent radius’ (r_{eq}) is defined such that a circle with that radius has the same area as given in CERCLIS, the ROD (for sites with no area given in the CERCLIS database), the Envirofacts database, site fact sheets, or site listing narratives. This creates a pseudo-site. Sites with no area data given and those shown with zero area are treated as points. The equivalent area circle is centered on the geographical coordinates given in CERCLIS, and then a set of circles is created, centered on the same point, having radii or r_{eq} +0.5, r_{eq} +1.0, r_{eq} +1.5, r_{eq} +2.0, r_{eq} +2.5, and r_{eq} +4.0 miles. Bins for population and housing data are created based on these circles. The reasons for choosing these distances for bins is to match previous work in the literature in order to make the benefits transfer analysis in Chapters 4 and 5 more reliable (Lybarger et al. 1998; Gayer, Hamilton, and Viscusi 2000; Kiel and Zabel 2001). The area with the circle of equivalent radius (r_{eq},) is considered ‘on site’ and each of the rings created by adjacent pairs of circles is designated by the distance of the outer circle from the edge of the onsite circle we have defined. Thus the smallest ring is the 0.5-mile ring and extends from the edge of the onsite area to 0.5 miles away. The largest ring has an inner boundary r_{eq}+2.5 miles from the CERCLIS location and an outer boundary r_{eq}+4.0 miles away.

Figure 3.5 shows a schematic of how the equivalent radius circle might look for a hypothetical site. In this figure, the area of the site is less than 100 acres, so r_{eq} is under a quarter-mile. Only the first two radii are shown.

[27] Hamilton and Viscusi were able to obtain precise boundaries for NPL sites by using the RELAI database, which is no longer maintained by the USEPA (Hamilton and Viscusi 1999, 253).

Figure 3.5. Construction of Equivalent Area and Radii for Population Estimation

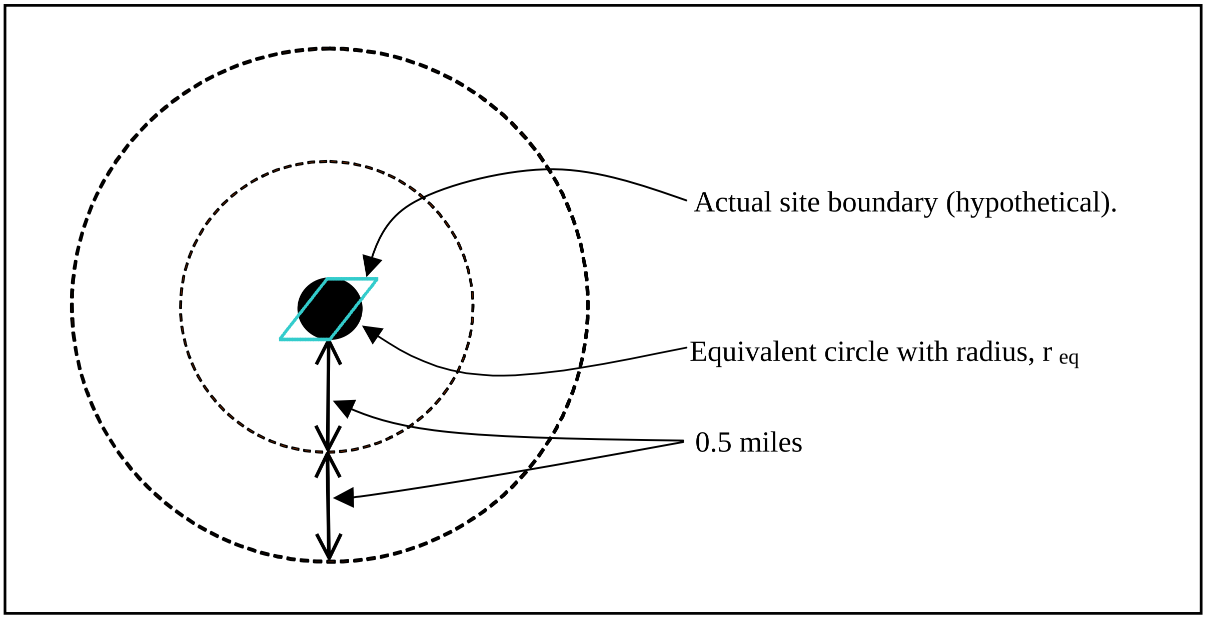
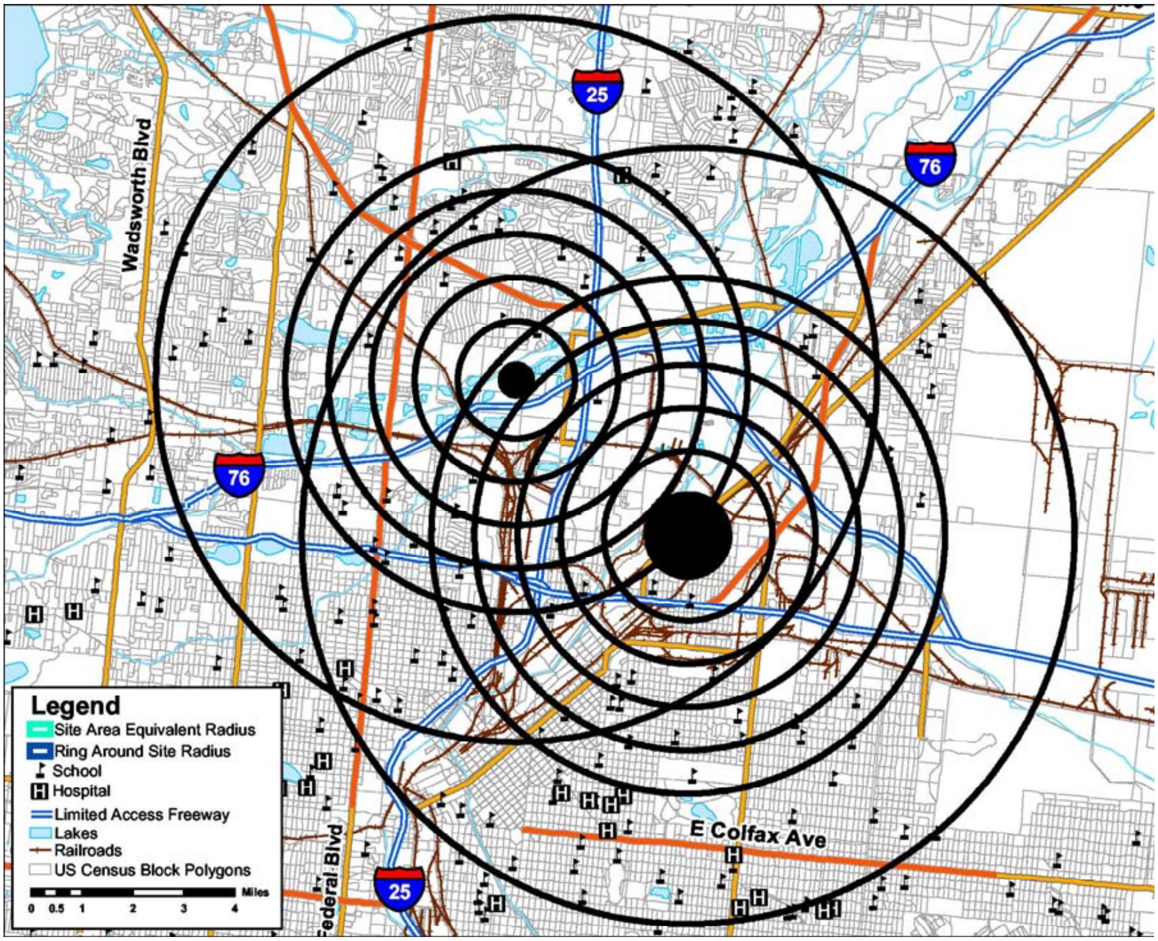


Figure 3.6 illustrates the results of this procedure for two sites in Denver, Colorado. This figure also shows how the population data are arranged. The site areas are shown as solid black circles, and the distance rings are shown as thick black circles. Distance rings are shown for all of the half-mile rings out to 2.5 miles, as well as the 4-mile ring. The boundaries of the census blocks are shown in gray. For reference, major roads and water bodies are also shown. The geographic rings shown in Figure 3.6 correspond to the bins into which the population and housing data are placed.

The smaller of the two sites (to the northwest), Broderick Wood Products, encompasses 64 acres; the larger site, Vasques Boulevard, encompasses 456 acres. These sites are larger than most; the median site size for all NPL sites is 30 acres. However, the size of the area within 2.5 miles of these sites is much larger than the site areas themselves. The nearby area would be larger than the on-site area by an even greater margin for most NPL sites. This suggests that differences between the actual site boundaries and pseudo-site boundaries may not be very important in estimating population size or number of residences. Spot checks at NPL sites for which boundaries were known indicated this approach introduced only small (<2%) errors in estimates of the number of residences near NPL sites up to the 2.5-mile distance.

Figure 3.6 also shows that some locations are close to more than one NPL site, which raises the question of how best to count populations and residences near NPL sites. This problem can be more severe in locations with many NPL sites, such as the Grand Rapids, Michigan, area, as shown in Figure 3.7. This figure shows the pseudo-site areas and 2.5-mile rings for eight NPL sites, many of which overlap. Thus, many locations that are near one NPL site are also near several others.

Figure 3.6. Site Areas, Distance Rings, and Population Data for Two NPL Sites in Denver, Colorado



Populations in places near more than one NPL site may have greater potential exposure to hazardous substances, and they may be affected by multiple disamenities, but it is not clear how to treat such multiple exposures. It is unclear if the impact of each individual disamenity would be the same at places near multiple sites as the impact of the same disamenity at a place near only one NPL site. It is also not clear if the impacts (or exposures) would be additive, or more or less than additive; the result could well vary with the specifics at each site. The literature generally ignores the issue of multiple sites, and assumes locations (or receptors) are affected by only a single NPL site.

Figure 3.8 illustrates that the problem of proximity to multiple NPL sites is common nationwide. This figure shows the location of all of the places near NPL sites in the contiguous United States, including site areas plus areas within 2.5 miles of the boundary of the pseudo-sites. Note that this figure shows places near sites, not just the site areas themselves. The smallest circles seen are five miles in diameter and are associated with sites having either zero area or no area data in CERCLIS or related EPA documents. Spot checks of this figure, comparing circular areas to geographic features of known size, and to Figures 3.6 and 3.7, show that the figure is to scale. There are many concentrations of sites, as well as large individual sites, which create significant overlaps between areas. For instance, Long Island, New Jersey and eastern Pennsylvania have many overlapping circles, as do the areas near Boston, Salt Lake City, Minneapolis, Houston, and Los Angeles.

Figure 3.7. Site Areas, 2.5-Mile Distance Rings, and Population Data for NPL Sites in Grand Rapids, Michigan

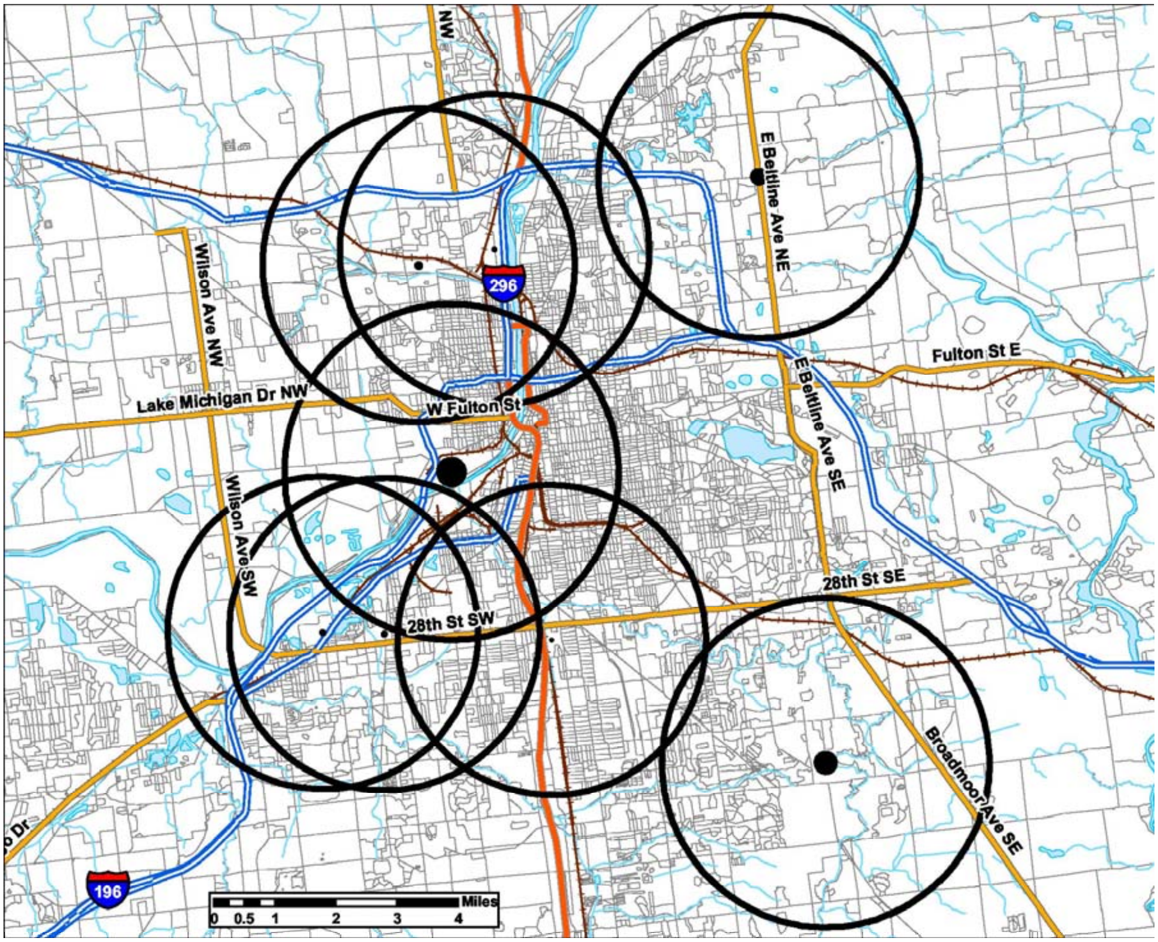
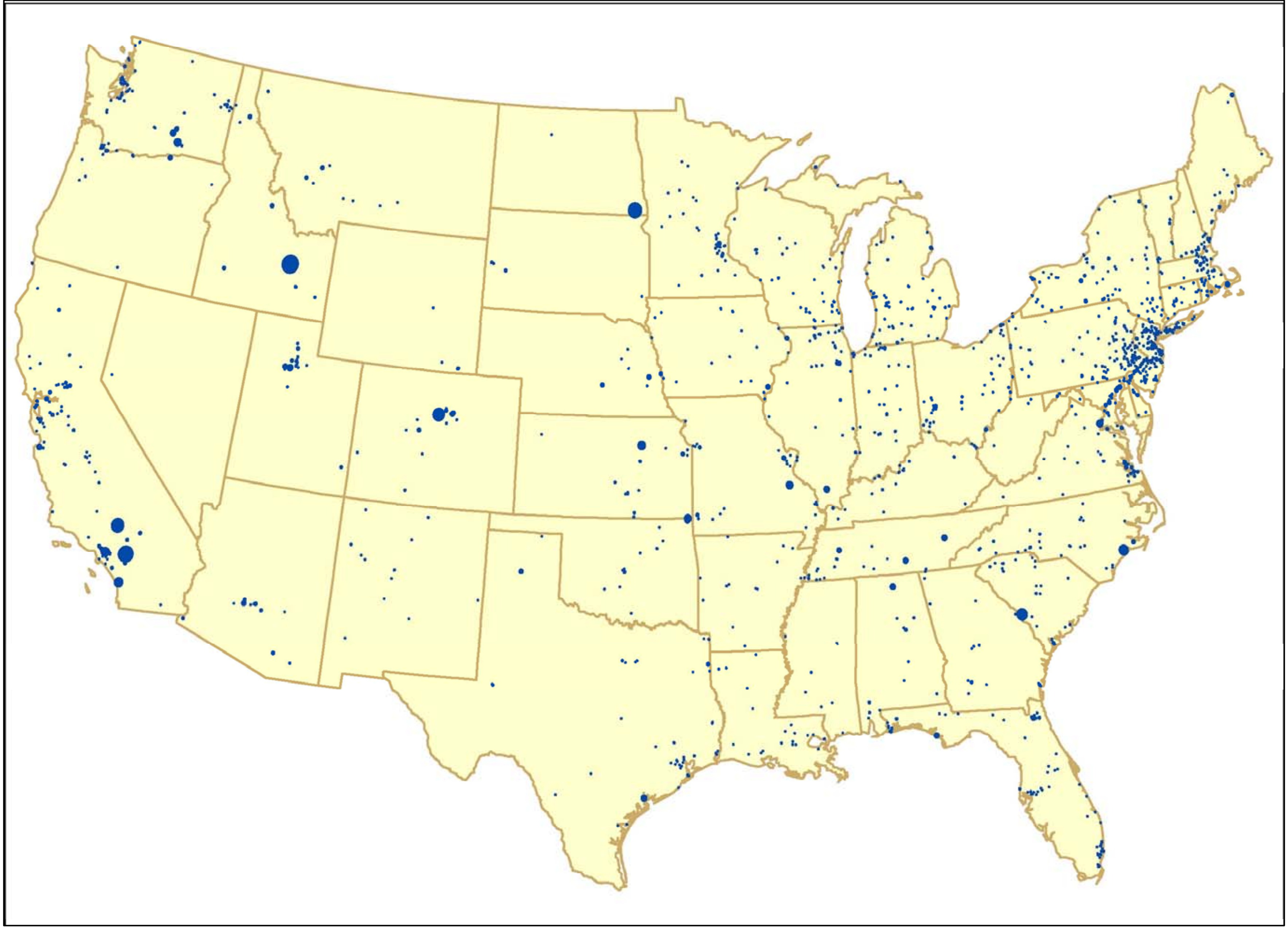


Figure 3.8. Places Near NPL Sites in the Coterminous United States (area plus r_{eq} = 2.5 mile circles)



Two approaches were used to count the number of residences and populations around sites: the multi-count approach, and the full-count approach. The multi-count approach is the simpler of the two and provides a non-arbitrary count of the number of people living near each site, making it useful for describing these sites individually. In the multi-count site population ($PS_{i,k}$), the number of people near each individual site are counted, irregardless of any other sites, for each bin. The number of people in each bin is determined by the fractional area of each census block that is within the ring corresponding to that bin, assuming uniform population distribution across the census block. In the multi-count total (PM_i), each person is counted once for every NPL site they are near and are put into the bins corresponding to the distance to each of the relevant boundaries, as shown in Equation 3.2. Six bins (i= 1 to 6) for this data are created using the equivalent area circle and the rings with radii or r_{eq} +0.5, r_{eq} +1.0, r_{eq} +1.5, r_{eq} +2.0, r_{eq} +2.5, and r_{eq} +4.0 miles.[28] To generate the multi-count of population, a census block (or block group) area fraction $\text{CBAF}_{i,j,k}$ was defined for each census block by NPL site and ring by the GIS software and applied as shown:

$$PS_{i,k} = \sum_{j=1}^{n} \left(CBP_{i,j,k} \cdot CBAF_{i,j,k} \right) \qquad \text{(Equation 3.1)}$$

$PS_{i,k}$ = the site population at site k in bin i, irrespective of other sites.

$CBP_{i,j,k}$ = the population in the j census block of bin i for site k.

$CBAF_{i,j,k}$ = the fractional area of the j census block within the i ring for site k.

n = the number of census block groups that intersect with the ring associated with bin i.

$$PM_k = \sum_{i=1}^{m} PS_{i,k} \qquad \text{(Equation 3.2, Multi-Count)}$$

PM_k = the multi-count population in all bins for site k.

$PS_{i,k}$ = the multi-count population in bin i for site k.

m = the number of bins (6).

However, the multi-count approach obviously has the potential for double-counting (or worse, as shown in the figures above) and so would not be appropriate when a sum of all people who live near NPL sites is needed. For this purpose, a full-count value is defined, (PF_i) in equation 3.3. In the full-count estimates, every person living within 2.5 miles of the boundary of an NPL pseudo-site is counted once, and he/she is placed in the bin corresponding to the distance from

[28] For simplicity, this report only contains the 2.5-mile values, except in sections on sensitivity analysis.

the closest boundary (residences are counted in the same way). Note that this is a set of six values, one for each bin.

In this approach, a census block (or block group) area fraction $CBAF_{i,j,k}$ was defined for each census block (or block group) by an area made up of the union of all *i* rings, excluding those areas already accounted for. The approach is described below:

$$PF_i = \sum_{j=1}^{n} \left(CBP_{i,j} \cdot CBAF_{i,j} \right) \quad \text{(Equation 3.3 Full Count)}$$

PF_i = the full-count population in bin *i* for all sites.

$CBP_{i,j}$ = the population in the *j* census block of bin *i*.

$CBAF_{i,j}$ = the fractional area of the *j* census block within the area made up of the union of all *i* bins for all NPL sites.

n = the number of census block groups that intersects with a given bin.

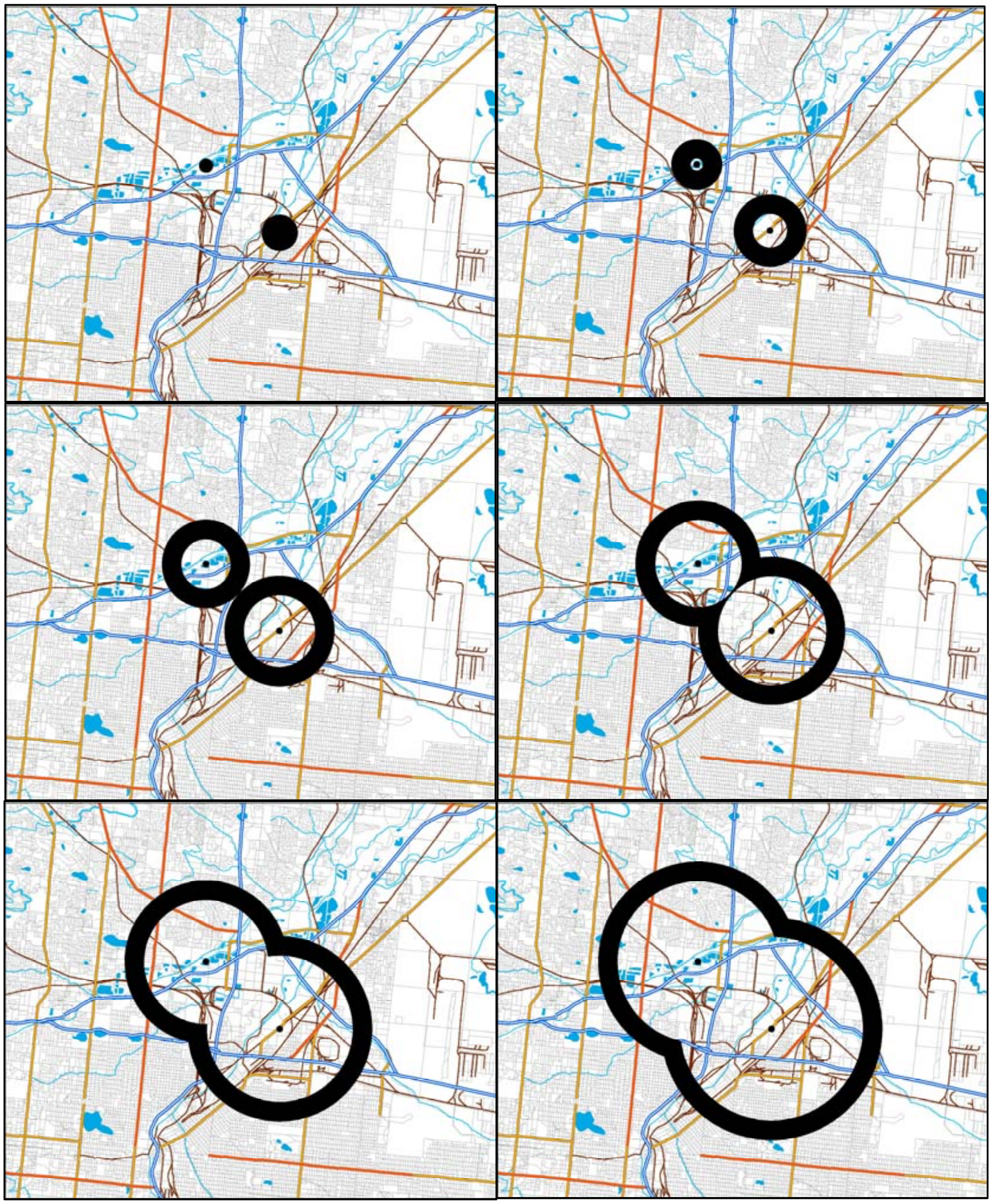
For example, in the full-count estimate, a person living close to the intersection of highways 25 and 76 in Figure 3.6 would be placed in the 0.5-1.0 mile bin because of proximity to the Broderick Wood Products site. In the multi-count estimate he/she would be counted twice, and would be placed in the 2.0-2.5 mile bin for Vasques Boulevard site as well as in the 0.5-1.0 mile bin for the Broderick Wood Products site.

The full-count procedure is illustrated in Figure 3.9 for the two Denver sites. The six panels of the figure indicate the area that is considered for each of the six bins. The first is made up of the two circular pseudo-sites; the second and third by two rings each; and the fourth, fifth, and sixth by figure eight-like shapes that avoid double counting. A similar plot of the six areas in the Grand Rapids area that correspond to the six data bins would produce a set of complex, discontinuous shapes.

Thus, the full-count procedure creates one value for each bin for the entire NPL or subset (e.g., the ROD group as defined in Table 3.3), for a total of seven values (the population on the site, plus each of the six rings). The multi-count procedure produces an array of values: seven for each site in the group being evaluated. For the entire NPL, this is (7 *x* 1,552 =) 10,864 values.

The full-count values are used in Chapters 4 and 5 to estimate benefits while avoiding double counting. The multi-count arrays are used below to characterize NPL sites. An important feature of the multi-count approach is that it does *not* preserve the association between population and individual NPL sites; only six values are calculated for population, which is the total number in each bin. This is acceptable because for the analysis conducted in Chapters 4 and 5, preserving the distance information is necessary, while preserving the site-specificity is not.

Figure 3.9. Full Count Procedure



<u>The Character of Sites</u>

This section discusses the *character* of NPL sites, using the groupings given in Table 3.3.

This analysis is based on insights from prior analysis, discussions with EPA staff and other experts, and the data available in CERCLIS. Parameters of interest include: location; dates that RODs are issued; dates of listing and construction completion (if applicable); the population living near the site; the size of the site (acres); whether the site is located in a Metropolitan Statistical Area (MSA); whether the site is a federal facility; and whether the site appears to be a "new" site type.

A distinction is often made between federal and non-federal sites, where the latter are hazardous waste facilities, industrial facilities (abandoned and active), and so forth, and the former might include those as well as military facilities, national laboratories, and the facilities uniquely found on them. For an example of this, see the Hanford case study on page 3-50. The distinction of federal and non-federal is usually made because of important differences in liability, response roles, and availability of the Trust Fund to pay for response. Moreover, federal facilities often are geographically large installations with numerous releases or potential releases that are somewhat separated and distinct from one another. However, it is not clear if there are significant differences in benefits from federal and non-federal sites, so this distinction is examined. Through FY 2003, a total of 175 federal sites were on the NPL, representing 11.3% of all sites.

Tables 3.4 through 3.7 provide descriptive statistics for these various characteristic features. Population and residence totals are based on full-count data, while the other values and statistics rely on site-specific data from the multi-count arrays.[29]

The most important parameters in the tables above are population and number of residences, since these are used as inputs to some of the calculation of benefits in Chapters 4 and 5. Another important issue is time from proposal to CC (construction completion or deletion), which gives an indication of the difficulty in remediating the site. The size is of interest as well.

Table 3.5 contains data that begin to describe the NPL and the groups defined in Table 3.3. Sites with RODs include most (81%) of all sites on the NPL (proposed, final, or deleted). Sites with RODS that are also in MSAs are a smaller number, but still include most (67%) of NPL sites. The study sites in the Property and HV groups are much smaller subsets (1% and 10% of NPL sites, respectively). Federal sites make up a relatively small subset of the NPL (11%).

A large majority (83%) of all NPL sites are within MSAs. Similar proportions of the ROD, HV, and Federal groups are within MSAs. By contrast, all of the NPL sites in the Property and MROD groups are within MSAs (the latter by definition).

A chi-squared statistical test can be applied to this data to test hypotheses about the differences in these sets. This statistic is calculated first to compare all the groups to the NPL and then to compare the other groups to the ROD group. In this case, there is one degree of freedom, so the critical value at the five percent level is 5.024. Thus, the data in Table 3.5 indicate that the hypothesis that the likelihood of a site being located inside an MSA is the same for the NPL, ROD, Property, HV, and Federal groups cannot be rejected at the five percent level. Similarly, the hypothesis that the likelihood of a site being located inside an MSA is the same for the ROD, Property, HV, and Federal groups cannot be rejected at the five percent level. This suggests that in terms of location relative to large numbers of people, all of these groups are similar, except for MROD, which by definition contains sites near population centers.

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[29] When percentages of residences and/or populations are discussed, these percentages are based on totals from the full-count data.

Table 3.5. Characteristics of NPL Sites

Group	Total	MSA	%	χ^2 NPL	χ^2 ROD	CC	%	χ^2 NPL	χ^2 ROD
NPL	1,552	1,264	81%	-	-	873	56%	-	-
ROD	1,263	1,044	83%	0.70	-	833	66%	1.04	-
MROD	1,044	1,044	100%	218	-	675	65%	-0.97	-2.19
Property	16	16	100%	3.64	3.35	7	44%	1.00	3.47
HV	150	125	83%	0.33	0.04	123	82%	37	15.7
Federal	175	154	88%	4.60	3.17	39	22%	73	123

Only a little more than half (56%) of all NPL sites have reached CC status, and Table 3.5 shows that there is more variation in this percentage for the other groups. The ROD, MROD, and HV groups have higher percentages of CC sites, while the Property and Federal groups have lower percentages. Using the chi-squared statistic to test the hypothesis that the likelihood of a site having reached CC status is the same for the NPL and other groups shows that only the Property group passes this test. Therefore the differences between the HV and ROD and the Federal and ROD groups are statistically significant at the 5% level.

The population data presented in Table 3.5 include both full-count and multi-count information, as appropriate. Totals for the larger groups (NPL, ROD, and MROD) are given using the full-count procedure, and avoid double counting. Totals for the smaller groups (Property, HV, and Federal) are sums of the individual site values created by using the multi-count procedure, and are accurate because there is little or no double counting among the sites in these groups. Thus, approximately 40 million people live near an NPL site, equaling 13% of the U.S. population; 11 million residences are near an NPL site, which equals about 14% of the national total. A distance of 2.5 miles is used to define "near," as discussed in Chapter 4.

Table 3.6 presents population data for places near NPL sites. The most striking feature of this data is that the mean population near Property sites is much larger (about twice as big) as the mean populations near NPL and ROD sites. Part of this difference can be explained by the fact that all of the Property sites are near population centers. However, the mean population near Property sites is still 80% larger than the mean population near MROD sites. A similar pattern is observed for the number of residences near sites, as shown in Table 3.6.

For this data, the *t* statistic can be used to test hypotheses, and because the number of observations is large, the critical value for the 0.05 percent level is 1.96. Thus, only for the Property group can the hypothesis that the mean of nearby populations is the same as the mean of nearby populations for all NPL sites be rejected. When compared to the ROD group, the hypothesis that the mean of nearby populations is the same as the mean of nearby populations for ROD sites can be rejected for the MROD, Property, and Federal groups.

Table 3.6. Populations Within 2.5 Miles of NPL Sites (thousands)

Group	Total	Mean	S.Dev	Median	Min	Max	*t* stat. NPL	*t* stat. ROD
NPL	40,000	37	83	17	0	2,200	-	-
ROD	32,000	34	58	17	0	1,200	1.09	-
MROD	30,000	40	62	23	0	1,200	-0.91	-2.18
Property	1,600	72	47	61	21	203	-2.99	-3.25
HV	4,900	33	40	15	0	205	1.16	0.43
Federal	7,500	43	49	27	0	323	-1.33	-2.12

Table 3.7 presents similar data for residences near NPL sites. The results of statistical hypothesis testing for the number of residences is similar to that discussed above, except that when compared to the ROD group, the hypothesis that the mean of nearby populations is the same as the mean of nearby populations for ROD sites can*not* be rejected for the Federal group.

The implications of the data in Tables 3.5 and 3.6 are that the Property sites have larger populations and larger numbers of residences near them than the other site groups and that these differences are statistically significant. These differences do not affect the estimates in Chapters 4 and 5, however, because mean populations and mean numbers of residences do not enter the calculations.

Table 3.7. Residences Within 2.5 Miles of NPL Sites (thousands)

Group	Total	Mean	S.Dev	Median	Min	Max	*t* stat. NPL	*t* stat. ROD
NPL	14,000	13	27	6.0	0	670	-	-
ROD	11,000	12	20	5.5	0	340	1.06	-
MROD	11,000	14	21	7.8	0	340	-1.11	-2.31
Property	420	26	15	23	7.3	58	-3.48	-3.75
HV	1,700	12	14	5.3	0	72	1.02	0.34
Federal	2,500	15	17	8.4	0	96	-1.07	-1.78

The time it takes a site to go from being proposed for inclusion on the NPL to reaching the status of CC is shown in Table 3.8. The only significant difference among the groups is for the Property group, which has a statistically significant longer mean time from Proposed to CC. This difference is smaller than the differences in population and number of residences, however, amounting to only a 25% increase. By looking at the medians and ranges for this value reported for the groups, it appears that the difference is due to the exclusion of sites with quicker (less than 7-year-long) remedial action processes from the Property group. However, as discussed in Chapter 5, it is not clear that this difference has any impact on the estimate of the benefits associated with NPL remedial actions.

Statistics describing the area of NPL sites are given in Table 3.9. As discussed below, these data are different from the nearby population and nearby residence data in that a few large sites dominate the area of NPL sites. Thus, the standard deviations are larger than the mean values for all the groups. The median values are therefore more informative. The median area for the NPL, ROD, and MROD sites is 30 acres; the median area for the Property sites is 33 acres. The HV sites tend to be smaller, with a median of only 17 acres. In this table, it is the Federal sites that stand out; these 175 sites account for most (67%) of the area of all NPL sites, and, naturally, have much larger mean and median areas.

Table 3.8. Time from Proposed NPL Listing to CC (years)

Group	Mean	S.Dev	Median	Min	Max	*t* stat. NPL	*t* stat. ROD
NPL	12	4	11	0	21	-	-
ROD	12	4	11	2	21	-0.44	-
MROD	12	4	12	2	21	-0.95	-0.54
Property	15	4	15	8	21	-2.05	-1.99
HV	12	4	12	4	21	-0.46	-0.25
Federal	12	4	11	4	20	-0.03	0.10

Table 3.9. Area of NPL Sites (thousands of acres)

Group	Total	Mean	S.Dev	Median	Min	Max	*t* stat. NPL	*t* stat. ROD
NPL	5,400	3.5	34	0.030	0	910	-	-
ROD	4,600	3.7	36	0.030	0	910	-0.14	-
MROD	2,300	2.2	19	0.030	0	450	1.24	1.25
Property	1.5	0.093	0.111	0.033	0	0.33	3.93	3.48
HV	17	0.113	0.439	0.017	0	3.2	3.91	3.46
Federal	3,600	21	86	3.6	0	910	-2.61	-2.57

The population and area data for all NPL sites are presented below in Figures 3.10 through 3.13 in order to provide a better characterization. Figure 3.10 shows the cumulative distribution of nearby populations for all NPL sites, sorted in two ways: by population, and by area.

The data in Figures 3.10 through 3.13 show that the size distribution of NPL sites is dominated by a small number of sites, but that these sites have relatively few people near them. Only six sites (0.4% of the NPL) make up 53% of the total area of all NPL sites. Table 3.10 gives the name, state, and size of all NPL sites larger than 100,000 acres. Of these ten sites, four are military bases, two are associated with the Department of Energy's nuclear weapons infrastructure, two are large ground water contamination sites, and two are former mining sites. Although these sites are very large, relatively few people are near them (only about 2.2 million, or 7% of the total population near NPL sites.) Of this total, about half are associated with a single site (Newmark). The ten largest sites in the coterminous United States are identified in Figure 3.14. Of the largest NPL sites, only Ft. Wainwright in Alaska is missed. The dominance of large sites is further seen in the fact that only 66 sites (4% of all NPL sites) make up 90% of the area of all NPL sites. However, only 11% of population near NPL sites is near these large sites. In addition, only two of these large sites are in the eastern part of the United States, while four of them are in southern California.

Figures 3.10 through 3.13 also show that there is little correlation between NPL site size and the population near NPL sites. The 170 NPL sites with the greatest nearby populations (11% of the total) have 50% of the total nearby population, while these sites represent 22% of the area of all sites. Similarly, 90% of the nearby population is associated with only 725 sites (47% of all NPL sites), but these sites have only 63% of area of all NPL sites.

Figure 3.10. Cumulative Population Distribution Near All NPL Sites

Figure 3.11. Distribution of Populations Near All NPL Sites (note logarithmic scale)

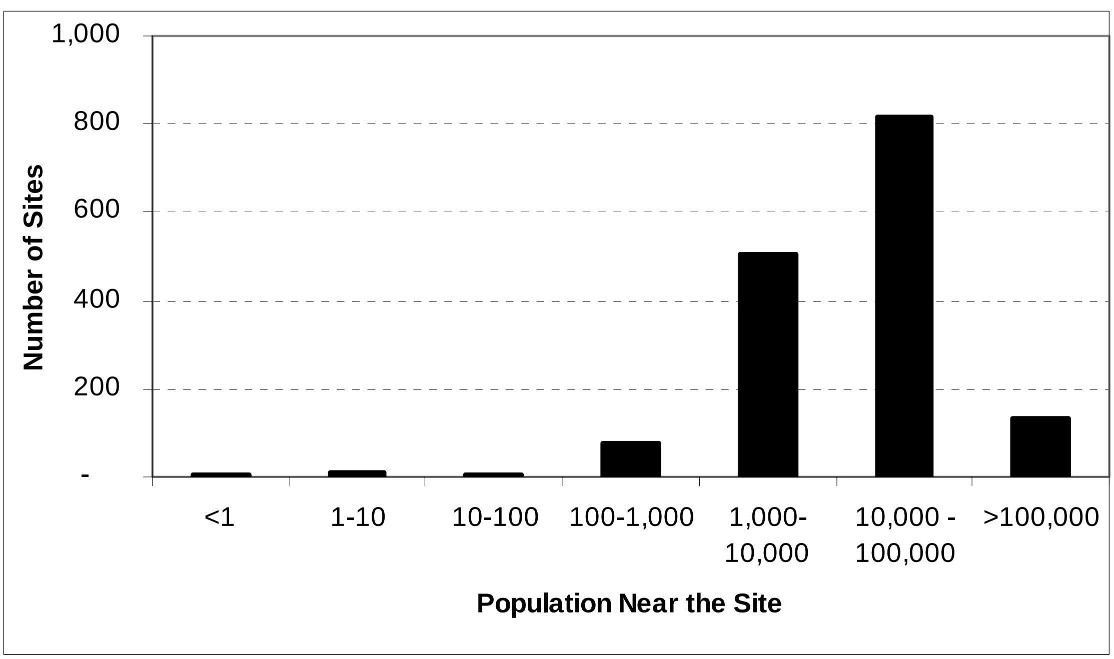


Figure 3.12. Cumulative Distribution of the Area of All NPL Sites

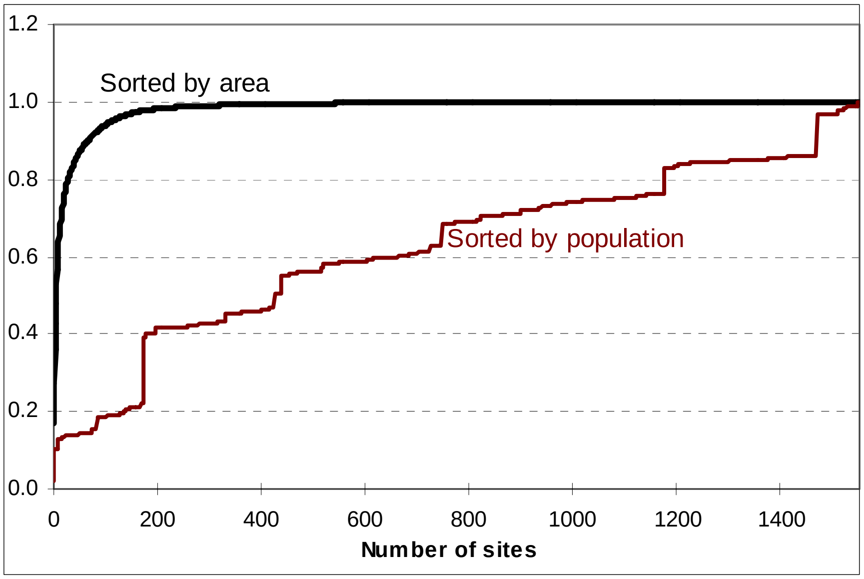
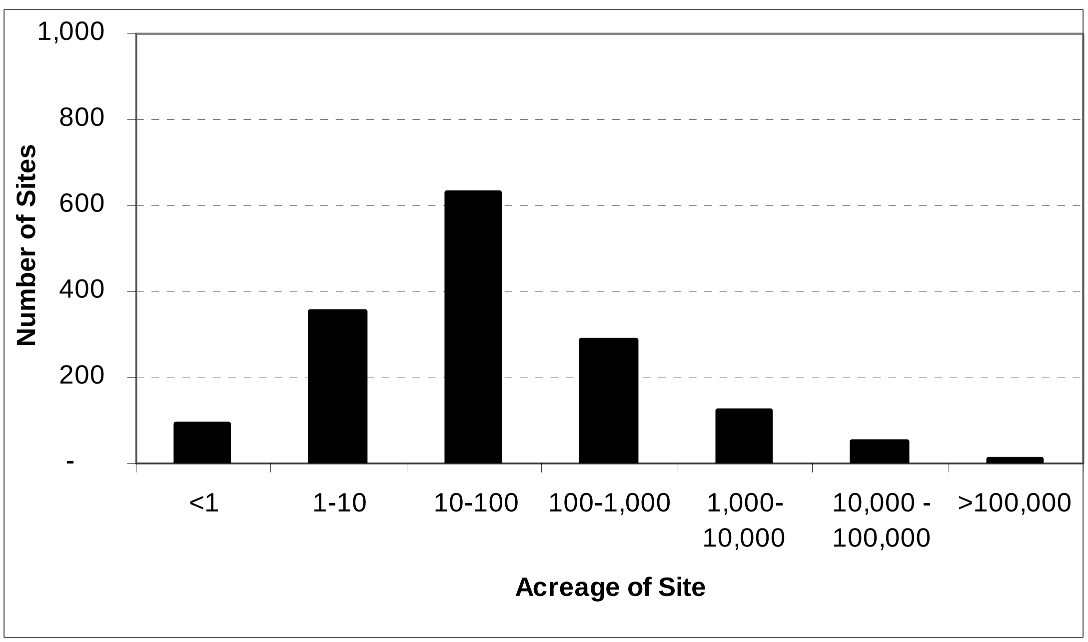


Figure 3.13. Distribution of NPL Site Areas (acres, note logarithmic scale)



These figures show that most NPL sites (824, or 53% of all NPL sites) have nearby populations of 10,000 to 100,000 and almost all (1,420, or 91% of all sites) have nearby populations of less than 100,000.

Those NPL sites with nearby populations of more than 250,000 are shown in Table 3.11. These sixteen sites account for about fifteen percent of the total population near all NPL sites. Three sites appear on both Tables 3.10 and 3.11: Newmark Ground Water, San Gabriel Valley (Area 3), and Camp Pendleton Marine Corps Base. All three of these sites are in southern California, and ten of the sixteen sites in Table 3.11 are in southern California.

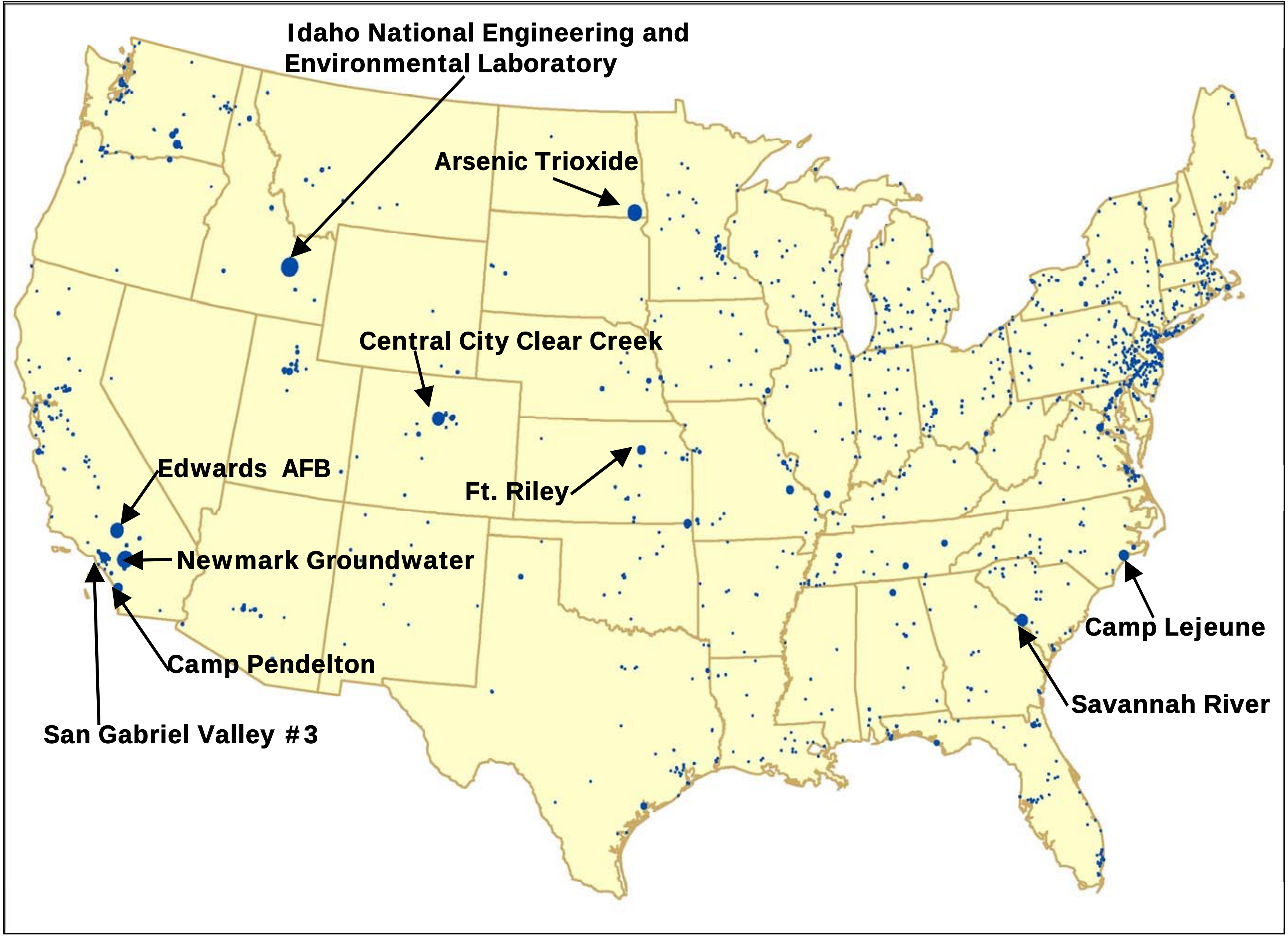
Table 3.10. NPL Sites Larger than 100,000 Acres

Name	**State**	**Size (acres)**
Fort Wainwright	AK	911,604
Idaho National Engineering Laboratory	ID	569,598
Newmark Ground Water	CA	447,998
Arsenic Trioxide Site	ND	363,520
Edwards Air Force Base	CA	301,000
Central City, Clear Creek	CO	255,999
Savannah River Site	SC	198,399
Camp Lejeune Military Reservation	NC	151,039
Camp Pendleton Marine Corps Base	CA	125,000
San Gabriel Valley (Area 3)	CA	108,800

Table 3.11. NPL Sites with Nearby Populations Over 250,000

Name	**State**	**Nearby Population**
San Gabriel Valley (Area 3)	CA	2,227,129
Newmark Ground Water	CA	1,168,434
San Fernando Valley (Area 4)	CA	712,205
Quanta Resources	NJ	634,671
Radium Chemical Co., Inc.	NY	630,826
San Fernando Valley (Area 3)	CA	492,427
Grand Street Mercury	NJ	434,146
San Fernando Valley (Area 2)	CA	355,919
San Gabriel Valley (Area 2)	CA	336,839
Camp Pendleton Marine Corps Base	CA	322,880
San Fernando Valley (Area 1)	CA	316,778
Cooper Drum Co.	CA	282,343
Austin Avenue Radiation Site	PA	277,236
Lansdowne Radiation Site	PA	256,287
Glen Ridge Radium Site	NJ	255,001
San Gabriel Valley (Area 1)	CA	252,404

Figure 3.14. Areas Near NPL Sites and the Ten Largest NPL Sites in the Coterminous U.S. States



The data presented in Figures 3.10 and 3.11 are reproduced below for each of the groups listed in Table 3.3. In general, the figures below illustrate the insights of the statistical tests discussed above (that they are all similar with the exception of the Property group).

Figure 3.15. Cumulative Population Distribution Near ROD Sites

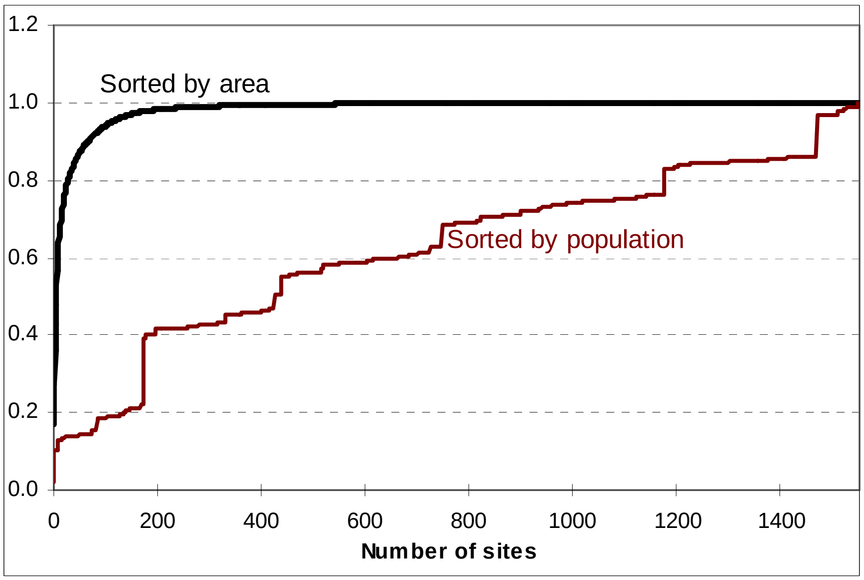


Figure 3.16. Distribution of Populations Near ROD Sites (note logarithmic scale)

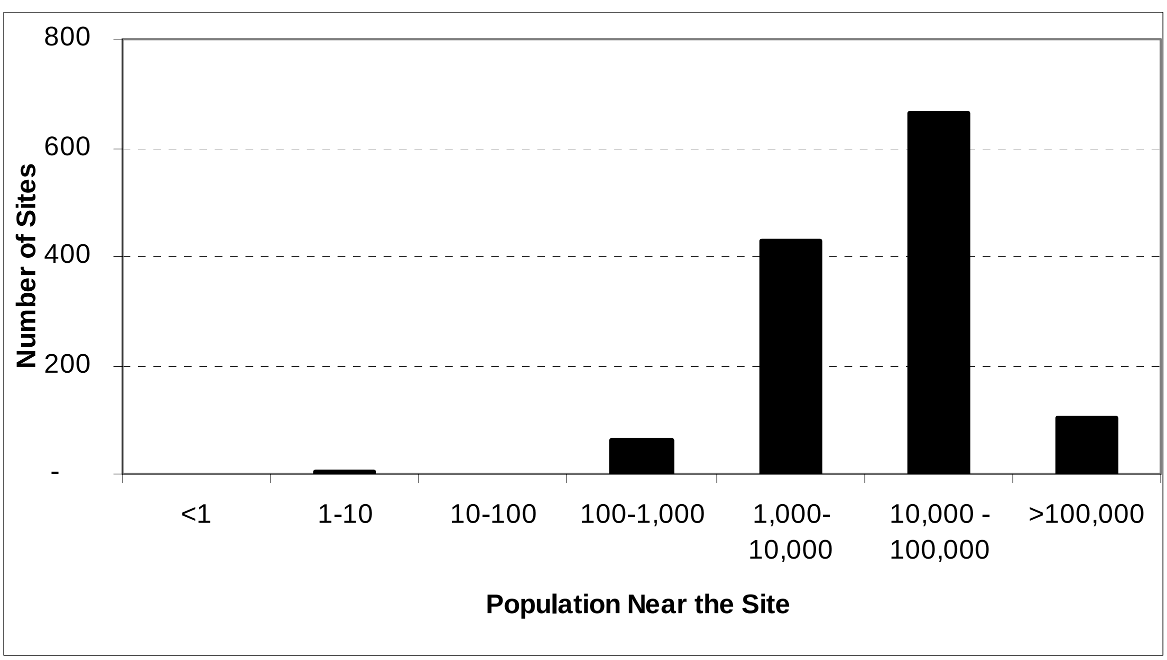


Figure 3.17. Cumulative Population Distribution Near MROD Sites

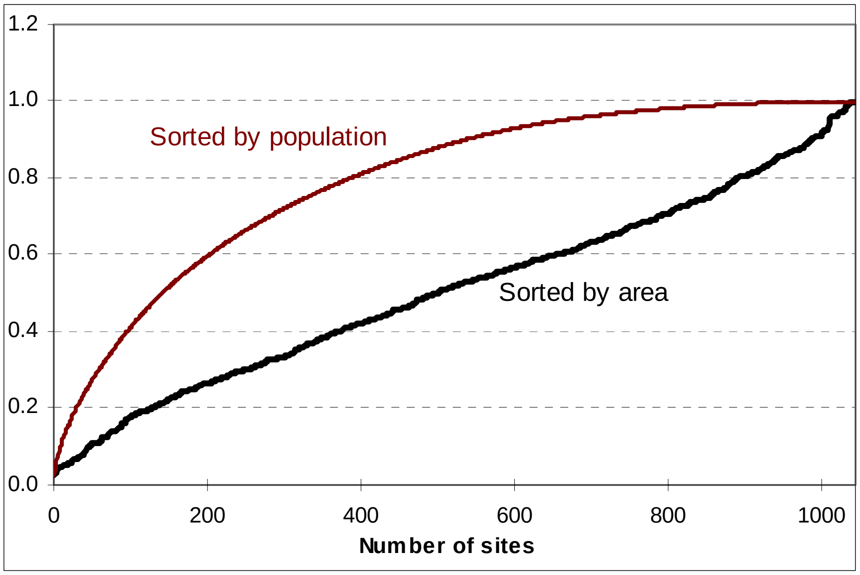


Figure 3.18. Distribution of Populations Near MROD Sites (note logarithmic scale)

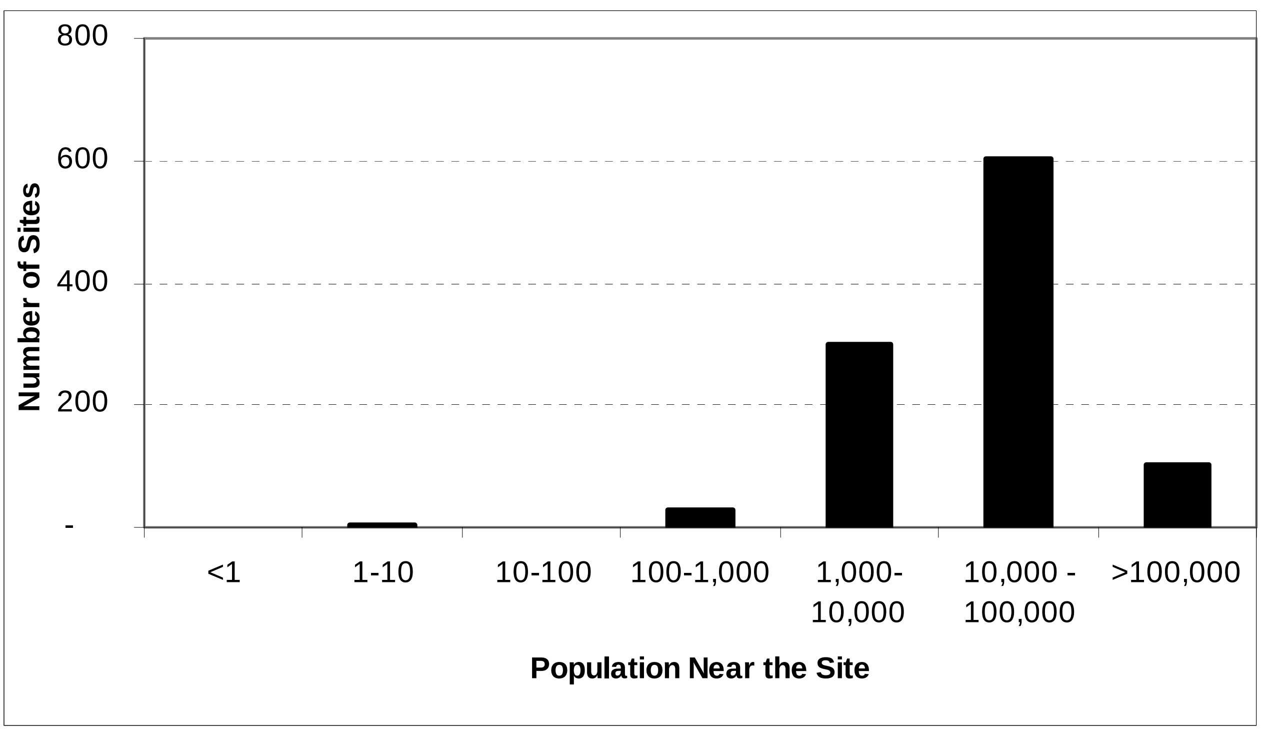


Figure 3.19. Cumulative Population Distribution Near Property Sites

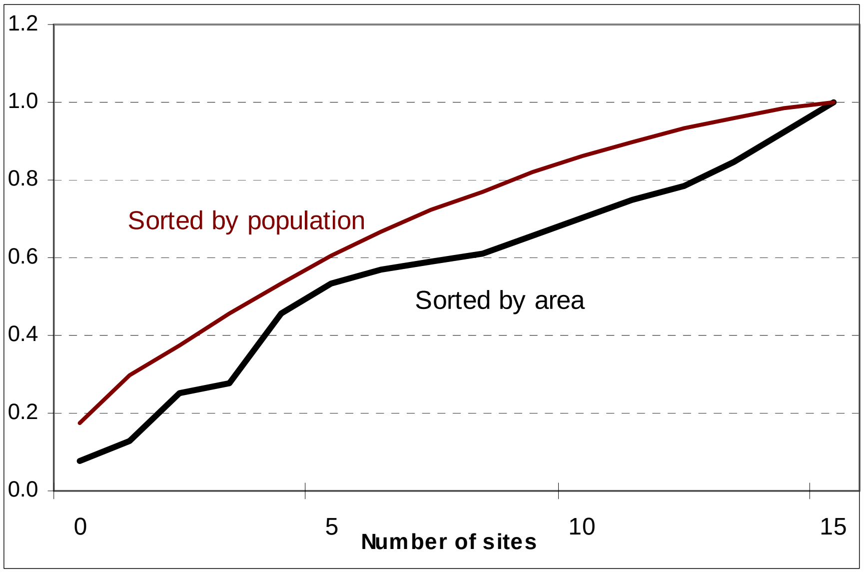


Figure 3.20. Distribution of Populations Near Property Sites (note logarithmic scale)

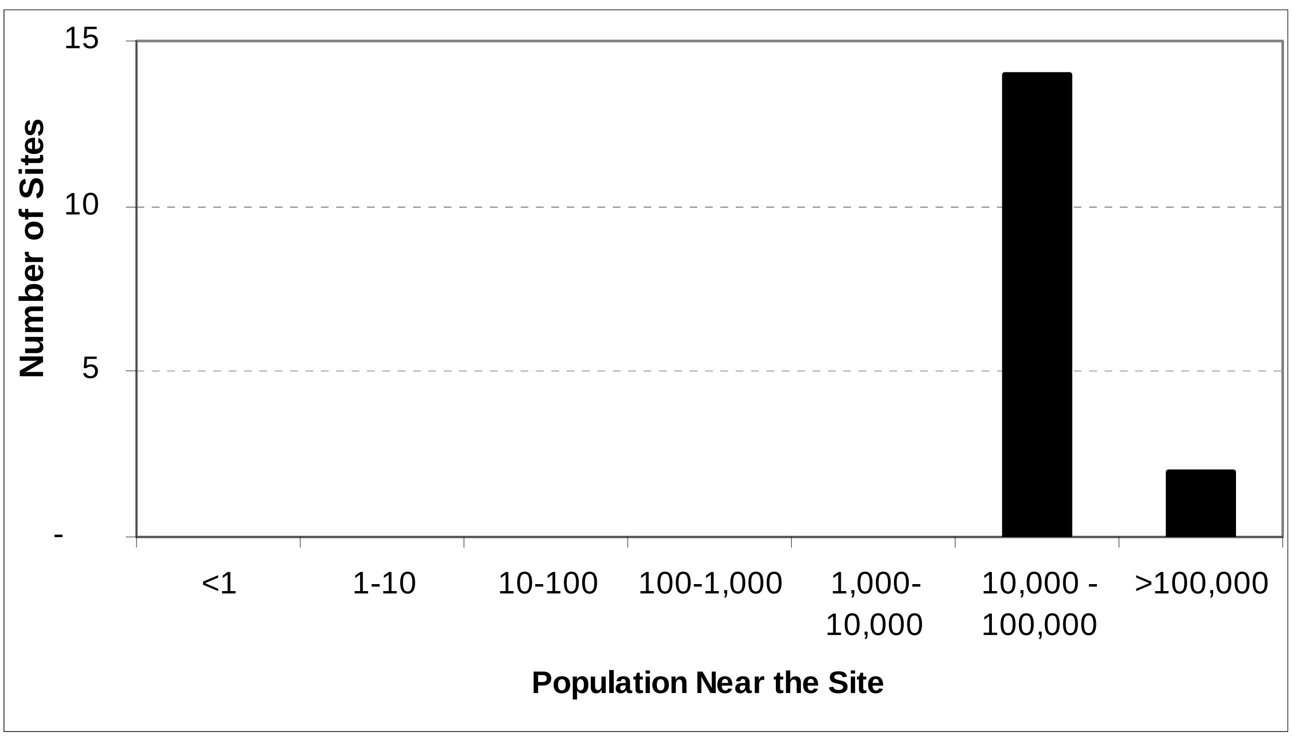


Figure 3.21. Cumulative Population Distribution Near HV Sites

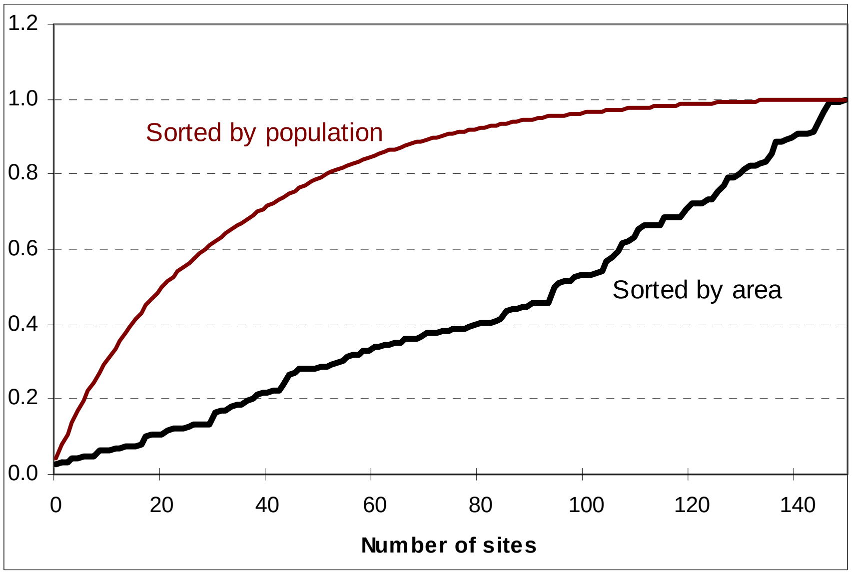


Figure 3.22. Distribution of Populations Near HV Sites (note logarithmic scale)

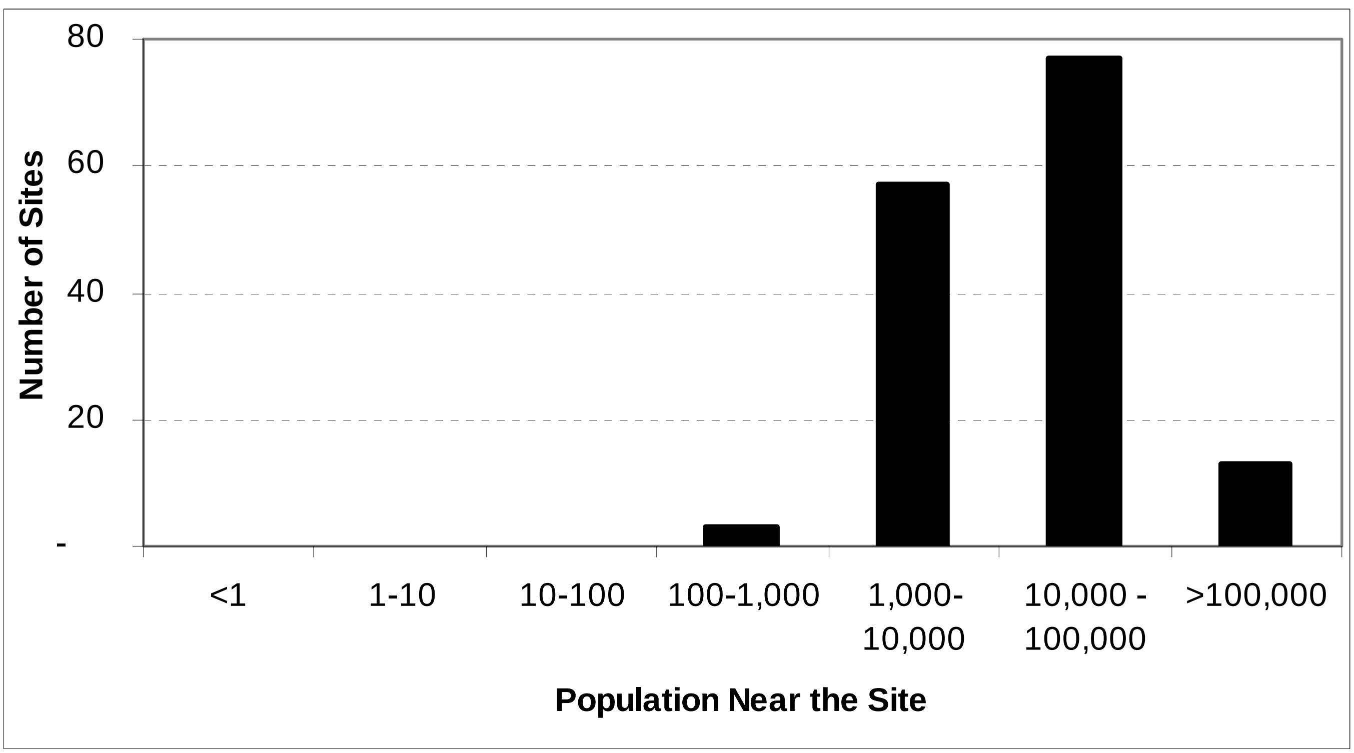
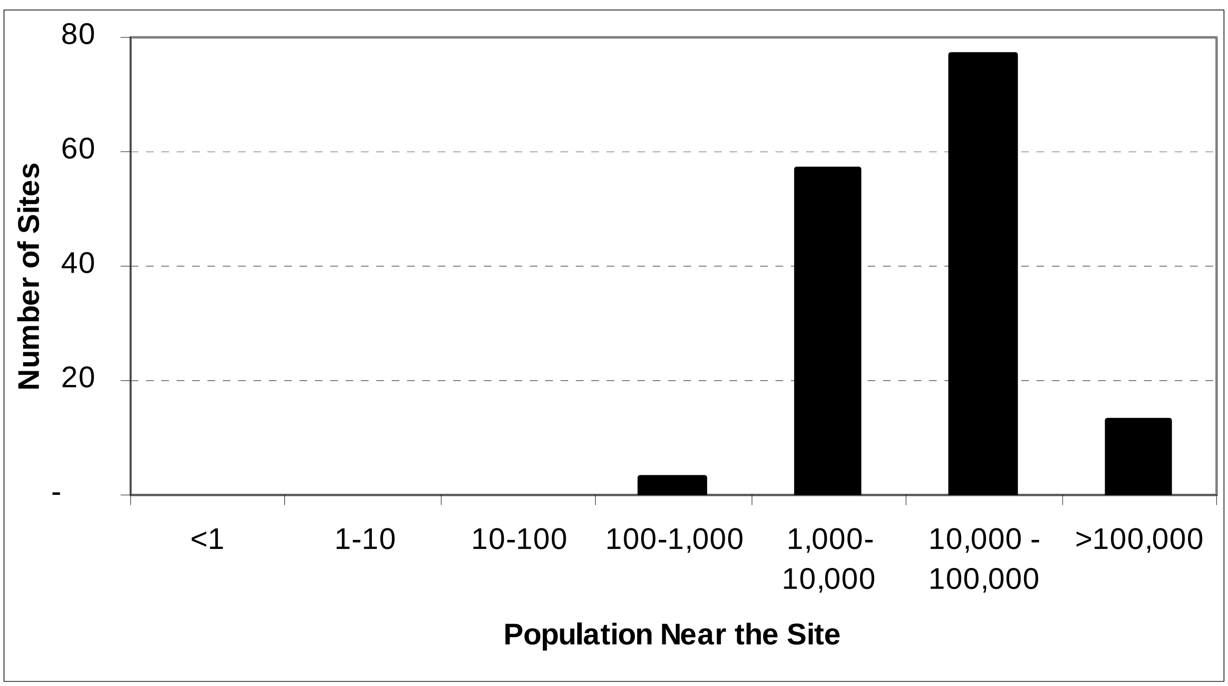


Figure 3.23. Cumulative Population Distribution Near Federal Sites

Figure 3.24. Distribution of Populations Near Federal Sites (note logarithmic scale)



Case Study: Hanford

Many of the largest and most challenging NPL sites are associated with current and former military bases and nuclear weapons facilities, such as the Hanford Nuclear Reservation in southeastern Washington State.TP[1]PT During World War II, the U.S. government created this and other research and manufacturing operations for the Manhattan Project. The 586-square-mile site continued to play an important role in the nation's defense for more than 40 years during the Cold War. The Atomic Energy Commission was in charge of Hanford from the 1940s until 1977 when Congress created the U.S. Department of Energy (DOE), which then took over Hanford's management. Today, the site is undergoing the world's largest environmental cleanup, involving both chemically toxic materials and radionuclides.

The problems being addressed at Hanford include more than 50 million gallons of high-level liquid waste, 2,300 tons of spent nuclear fuel, 12 tons of plutonium, 25 million cubic feet of solid waste, and 270 billion gallons of contaminated ground water. The problems are spread out over about 80 square miles and are located at more than 1,700 waste sites and 500 contaminated facilities. Sixty percent of the nation's high-level radioactive wastes are stored at Hanford in aging, deteriorating tanks. If they are not cleaned up, these wastes are a threat to the Columbia River, which flows next to the Hanford site. Over half a million people live within 50 miles of Hanford, and over two million people live downstream, many in or near Portland, Oregon. In May 1989, the Environmental Protection Agency (EPA), the Washington State Department of Ecology, and DOE signed an agreement providing a framework for Hanford's cleanup. In October of the same year, an area totaling 208 square miles was listed on Superfund's National Priorities List (NPL). The enormous task of cleaning up contamination at Hanford was made more manageable by dividing the contaminated property into four NPL sites known as Areas 100, 200, 300, and 1100.

The 26-square-mile 100 Area was contaminated by nine nuclear reactors, the last of which shut down in 1988. Cooling water contaminated with radioactive and hazardous chemicals was discharged to both the Columbia River and infiltration trenches. As a result, 11 square miles of ground water are contaminated with hexavalent chromium, radioactive strontium-90, carbon-14, and tritium (radioactive hydrogen). Though the ground water is not directly used for drinking, it discharges into the Columbia, which provides drinking water to the 100,000 residents of Richland, Pasco, and Kennewick just downstream of Hanford. The ground water is being cleaned by three pump-and-treat systems, two of which are removing hexavalent chromium, and one of which is removing strontium-90. An in-situ barrier has been installed to contain the hexavalent chromium-contaminated ground water. Contaminated solid wastes buried on the site are also being removed as part of the remediation; over 2 million tons of contaminated soil and debris have been removed.

The Hanford 200 Area covers approximately 60 square miles of land and over 120 square miles of contaminated ground water. It contains the former chemical processing plants and waste management facilities used to process, finish, and manage nuclear materials, including plutonium. About one billion cubic yards of wastes were disposed of in more than 800 locations in the 200 Area. This resulted in the contamination of soil and ground water with tritium, uranium, cyanide, carbon tetrachloride, and technetium. Since 1992, a soil vapor extraction system has removed 168,000 pounds of carbon tetrachloride. Ground water systems have removed 10,000 pounds of carbon tetrachloride, 220 pounds of uranium, and one pound of technetium-99. Nonetheless, some exposure may be ongoing due to this site. For instance, the City of Richland's surface water intakes on the Columbia River contain low levels of tritium.

TP[1]PT Most of the information used to create this case study was obtained from various documents available on the Internet in August 2004. These sources include: www.hanford.gov/history/0435/0435-1st.htm; EPA's Site Summary for the Hanford 100, 200, 300, and 1100 Areas, http://yosemite.epa.gov/r10/nplpad.nsf/; TUwww.hanford.gov/ORPreporter/index.cfmTU; EPA's Hanford 1100 Area Case Study, February 2000, www.epa.gov/superfund/programs/recycle/success/casestud/hanfcsi.htm. In addition, please see Gephart 2003; Washington State Department of Ecology 1997; Washington State Department of Health 1997.

Case Study: Hanford (cont.)

The 1.5-square-mile Hanford 300 Area was an industrial complex and disposal area. The Department of Energy fabricated fuel for nuclear reactors and conducted research and development in the 300 Area. The 300 Area also received 27 million cubic yards of wastes. The liquid wastes percolated down through the highly permeable sand and gravel aquifer, contaminating the ground water and the Columbia River and endangering the drinking water intakes downstream. Ground water and soil contaminants include uranium, volatile organic compounds (VOCs), strontium-90, tritium, cobalt-60, copper, polychlorinated biphenyls (PCBs), and chromium. Soil contamination is being addressed via excavation and removal; 530,000 tons of contaminated soil and debris had been removed as of June 2000, with more excavation planned. The ground water contamination is being addressed by monitored natural attenuation.

The Hanford 1100 Area covers 120 square miles, approximately one mile north of Richland, Washington. The 1100 Area provides maintenance services to other areas of Hanford. The Yakama Nation has exclusive fishing rights to the Yakima River, which borders the 1100 Area. Wells near the 1100 Area are contaminated with VOCs, including trichloroethylene. The soil was contaminated with asbestos, heavy metals, and PCBs. This contamination was addressed by excavating 295 cubic yards of contaminated soil and disposing of it at a permitted facility. Ground water will be monitored until natural processes clean it over time. The 1100 Area was deleted from the NPL in September 1996. Since that time, new enterprises have begun operating at the 1100 Area; these include a rail hub and a locomotive maintenance and repair facility.

The cleanup at Hanford demonstrates how EPA can work with state and federal agencies to address widespread contamination at huge federal facilities even when high-level radioactive waste is involved. EPA, DOE, and the Washington State Department of Ecology are pooling resources and using techniques developed at other Superfund sites to protect the Columbia River and the health of populations surrounding Hanford. In some cases, decisions about remediation at the Hanford site will be guided by Washington state standards, as part of the applicable or relevant and appropriate requirements (ARARs) provisions of the Superfund Amendments and Reauthorization Act (SARA). This case also illustrates large-scale examples of the use of institutional controls (i.e. access restrictions) to prevent exposure while remedial actions are designed and implemented. Due to the magnitude of the contamination at this site, the operation and maintenance phase of the remedial actions is likely to continue for a lengthy period.

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